

Dr. Hasan Jawaid Khan, Dr. Saumyadip Sarkar

Editor, Science Reporter

Thank you for an invitation. Responded all your queries and let me know in case you require additional details

Best wishes

TVR

Dear Dr Ramachandra,

Thank you very much for agreeing for an interview with Saumyadip Sarkar. He is a young and enthusiastic reader of Science Reporter and I am sure this would be highly encouraging for him.

Without meddling with any of the questions that Saumyadip has put to you, I would like to ask you a few questions too, which can be a part of Saumyadip's interview, if that is okay with you.

Dr. Hasan Jawaid Khan, Responses to your questions:

1. The water crisis in many parts of the country does not augur well for the future. Your team has come out strongly against encroachment and commercialisation of urban wetlands. In fact, you have even gone to the extent of suggesting that builders and developers who have destroyed the wetlands of Bangalore should be thrown into the Arabian Sea. How strategically important do you think could be wetlands in taking care of the water crisis that faces us every now and then?

Wetlands play a pivotal role in ensuring the water security and also aid in remediation and aptly often known as 'kidneys of the landscape. Our study shows that groundwater table in the region gets altered with the removal of wetlands (lakes), evident from the decline to 300-400 m from 100-200 m (in the presence of wetlands). Similar studies done in Western Ghats confirms the role of marsh lands, swamps in retaining the water. The aquatic ecosystems, with a good native vegetation in the respective watershed region helps in sustaining the water, which supports and sustains peoples' livelihood. Considering the looming threat of water scarcity due to mismanagement of natural resources, I strongly feel all violators whose action certainly deprive our future generation of basic needs (water, etc.) are to be punished without any mercy. Let us be stringent, if we are concerned about our country's future as well as welfare of our next generation, we need to implement environmental norms to safeguard ecosystems.

2. Shouldn't the Chennai floods have been a wake-up call for authorities to realise the sanctity and importance of conserving and nurturing wetlands?

High quantum of rainfall is the indication of changes in climate (due to global warming) and higher loss of life and property highlights mismanagement of natural resources due to inefficient and incompetent decision makers with the removal of interconnectivity and marshlands (due to unauthorised occupation/ encroachments). We need to make decision makers accountable for each of human-made calamities. Due to the short term goals of this section of the society, the country and people pay heavy price. Decision makers need to have vision of sustaining natural resources than optimising proceeds during their professional career for themselves. Chennai, J & K and Uttarakand floods are certainly wakeup call for all sensible citizens of our country. We need to intervene and reverse the damages (due to illogical and senseless unplanned activities) done by the current generation decision makers, otherwise certain doomsday ahead.

2. How do you propose reinvigorating wetlands throughout the country? Are the current rules and regulations enough to prevent the wetlands and other water bodies from being appropriated and mauled by vested interests?

Unfortunately next generation will have to pay heavy price (our children will not have water – quality and quantity) for irresponsible act of current generation in allowing abuse of ecosystems (such as wetlands, etc.). Threats to wetlands are (i) too many para-state agencies and fragmented or un-coordinated governance, (ii) poor or inefficient regulatory mechanism, (iii) nexus of bureaucrats, politicians and mafia (land, water and waste)

Rejuvenation of lakes / wetlands involves:

- (i) Mapping of wetlands boundary and flood plains;
- (ii) Demarcating buffer zone (75 m) with regulated activities;
- (iii) Allowing only treated sewage into the lake;
- (iv) Integration of sewage treated plants with constructed wetlands and algae ponds would ensure the removal of nutrients (in treated water) – low cost option to remove nutrients. This model is working satisfactorily at Jakkur lake in Bangalore. Details are at

https://www.researchgate.net/publication/282152145_INTEGRATED_WETLANDS_ECOSYSTEM_SUSTAINABLE_MODEL_TO_MITIGATE_WATER_CRISIS_IN_BANGALORE

Efficient functioning of this model is evident from absence of nitrate in the groundwater wells in the vicinity of Jakkur lake. Earlier studies (before lake restoration) revealed higher amount of nitrate in these wells. Nitrate being carcinogenic, introduces cancer in humans. Now, with efficient removal of nitrate, 300+ borewell dependent families are consuming water without any pollutants (nitrates). This also demonstrates with appropriate technologies, we can ensure water security in the region.

- (v) Needs to decontaminate (by removing sediments with accumulated nutrients and trace elements)
- (vi) Bio-manipulation - introduction of taxa to remove nutrients etc.

More importantly we need to have a single agency to be the custodian with appropriate legal power to address the problems of pollution (solid and liquid waste disposal, encroachments of lake bed and storm water drains, etc.). We need to evict all encroachers without any humanitarian considerations and penalise polluters.

Valuation of wetlands goods reveal that the one which are in pristine state supports the local livelihood to an extent of Rs 10500 /hectare/day compared to the polluted wetlands (Rs 20 /day/hectare). These ecosystems provides food and also ensures water security, emphasis the need for conservation for our next generation.

3. You have also highlighted the importance of conserving the Western Ghats. How can a balance be achieved between the 'need' or yearning for development and the necessity of conserving natural habitats?

Well, Western Ghats constitutes only 2.5% of land mass but provides water and food security to the entire peninsular India. We have earmarked eco-sensitive regions in Western Ghats to be conserved for posterity. There are large scale encroachments in Western Ghats due to connivance of inefficient and dishonest decision makers with local mafia. All these encroachers (who are incidentally powerful with looting of resources) have formed formidable group, threatening even the survival of federal and central government. The government succumb to the pressure of encroachers (who constitute about 20% of total population). The presence of rubber plantations in erstwhile dense evergreen forest regions highlights the level of encroachment (which ranges from 30-40% in each taluk of Western Ghats districts. The present generation should not be so greedy and selfish in damaging the resources of future. We need to conserve Western Ghats as:

- The region is rich in biodiversity (flora and fauna – 4500+ flowering plants, etc.) – latitude 8-15 degree has highest biodiversity (plant, animal, and also humans).
- The Western Ghats is one among the 35 global hotspots of biodiversity and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. It harbours very rich flora and fauna and there are records of over 4,000 species of flowering plants with 38% endemics, 330 butterflies with 11% endemics, 156 reptiles with 62% endemics, 508 birds with 4% endemics, 120 mammals with 12% endemics, 289 fishes with 41% endemics and 135 amphibians with 75% endemics (http://wgbis.ces.iisc.ernet.in/biodiversity/pubs/ces_tr/TR122/index.htm).
- High mountains with native vegetation helps in maintaining precipitation. For example, in central Western Ghats, Saravathi river basin earlier was receiving rainfall more than 3500-4500 mm (orographic precipitation). Now in the sub-basins with native forest vegetation receives the rainfall 3500-4500, while the sub-basin with

degraded watershed has declined rainfall of 1700-1900 mm. The decline is due to deforestation and removal of native vegetation.

- Western Ghats forms watershed for many rivers and helps in sustaining water or water security. Our study reveals that, the sub basins with native forest cover (> 65%) had perennial streams, while sub basins with dominant monoculture plantations has seasonal streams (6-8 months depending on the extent of plantation cover) and sub-basins with degraded landscapes had streams which had water only for 4 months (that is only during monsoon). This emphasises the need for retaining native forest cover to sustain water in streams, which also gives food security.
- I suggest the government carry out digitisation of land parcels and make available this information to all. This helps in curtailing further encroachments and also to take immediate action against big violators of nature

Droughts in 278 districts or majority of districts in Karnataka further highlights the linkages of landscape cover and water availability. Current decision makers are not keen on conservation (as the revenue for them from the availability of resources are minimal). While, degrading the ecosystem and then come up with unrealistic projects (such as river diversion) would benefit the decision makers lobby (nexus of bureaucrats, contractors, engineers, etc.).

Our studies also reveal of interesting linkages of farmers suicide with deteriorating landscape or deforestation. In western Ghats districts we did not witness any suicide while neighbouring districts with higher rate of deforestation or degraded landscapes saw large scale farmers' suicide due to (i) water scarcity, (ii) inappropriate cropping in drier districts, (iii) dependence on GM crops (at the mercy of MNC's and moneylenders) than native varieties

Further, villages in the downstream of perennial streams (forested landscapes) grow three crops (as well as horticulture crops) compared to villages in the downstream of degraded landscape. The revenue generation in these villages (with perennial streams) had revenue at least 5 times higher than villages in degraded landscape.

We need to have sensible development and currently the 'development' is hijacked by violators of norms, etc. As politicians and bureaucrats are benefitted by these sections of the society, everyone take refuge of 'development agenda' to loot natural resources.

5. How has geospatial technology come to the aid of environmental warriors such as you in today's time and age?

Geospatial technologies (temporal remote sensing data with geoinformatics) has helped in understanding the landscape dynamics (linkages of land cover, hydrology, biodiversity and ecology) and helps in visualisation of likely changes. This has helped in convincing sensible decision makers (fortunately, we still have small fraction of decision makers) the need for sensible development while sustaining the natural resources. Our work in Western Ghats, bring out the implications of poor planning in ecologically sensitive regions. Refer our recent publication 'Geospatial analysis of fragmentation in Uttara Kannada district, India' at

- <http://wgbis.ces.iisc.ernet.in/energy/water/paper/Geospatial-analysis-of-forest-fragmentation/index.html>
- <http://wgbis.ces.iisc.ernet.in/energy/water/paper/researchpaper2.html#f>

Bangalore: Unliveable city

https://www.researchgate.net/profile/T_V_Ramachandra/publications

Our work in Bangalore and other 9 cities in India apart from land cover dynamics analysis in Western Ghats further highlights the strengths of geospatial technologies in sustainable management of natural resources.

We need to question decision makers who allowed contaminating Ganga River (in the name of development) and during the last four decades successive governments have to spend lot of public money (to rejuvenate). Recent announcement of Rs 20000 crores to clean Ganga (namami Ganga), further highlights that it is economical not to contaminate (controlling pollution at source) than contaminating and then spend public money to decontaminate. The approach of allowing polluters to contaminate, only helps in looting public money.

I hope you won't mind putting in a few questions of my own.

I have attempted answering all your queries. Due to academic session, took longer time than expected

Best wishes

TVR

Dear Dr. T.V. Ramachandra

It is a big honour for me to be assigned for this interview of yours on behalf of Science Reporter, monthly magazine under CSIR-NISCAIR. I am honoured that Mr. Hassan Javed Khan, Chief Editor at Science Reporter glad to accept this assignment. I would like to introduce myself as freelance scientific communicator and researcher of biological sciences. Here some of the questions been addressed on based on your journey of research, experiences and your success. There are lots to discuss although you may find few questions hence I would like to get maximum possible answers for the questions. The question can be edited before it is finally produced for publication. Please procure your healthy time to answer the following questions.

You are free to mail me if you need any clarifications or queries.

Q) Dr. T. V. Ramachandra, well known environmentalist and scientist at Indian Institute of Science, Bangalore; he is on strong focus after his recent research on deforestation and urbanization of Bangalore that provided a strong threat on environment. Before we carry on with scientific discussion, we would like to know more

about your childhood life. How you grown up as an environment lover and also how your parents or teachers influenced you throughout your career?

Comment: Though I was born and brought up in urban environment, I had opportunity to spend holidays in Western Ghats with my grandparents and other relatives. Interactions with native forests and pristine water sources and more importantly very sensible native population, have shaped my career path. Pristine nature and sensible knowledgeable elders helped in moulding personality. School teachers (mathematics and biology) certainly have role in shaping my career.

My teachers apart from giving opportunity to be the class leader (monitor), had given responsibility to take special classes (for my classmates, who were sluggish in studies) in the evenings. This gave an opportunity to understand the role and responsibilities of a teacher at a very young age. This assignment also made me disciplined and understanding responsibilities of a youngster. Probably, this also helped in improving my reading habits especially science magazines and inquisitiveness.

Q) Lets start off with current scenario. The global environment is a big word. We have been facing lot of problems like rise of pollution, urbanization to deforestation, global warming, and lot others. If you are asked about sustainability then how will you define based on its importance to current scenario? Please provide a brief account on the conclusions drawn based on the account of book chapter “Administrative reforms: towards sustainable practices”.

Comment:

Our constitution empowers citizens through decentralization of power, effective people's participation through state and non-state mechanisms, greater synergy and consolidation among various agencies and programmes of government, civil service reforms, transparency, rationalization of governmental schemes and mode of financial assistance to states, improved access to formal justice system to enforce rights, reforms and strengthening of land administration and harnessing the power of technology for governance. In contrary, policy-making takes place at the centre (macro-level), and the actual implementations at the end-user (micro-level), by the bureaucrats/administrators are mostly different than what was originally conceptualized or intended for, as implementation practices are embedded with colonial structures, bureaucratic autonomy and opaque systems leading to economic inefficiency, ineffectiveness and inappropriateness of some of these set-ups (74th amendment).

Sustaining the natural resources through effective local level planning towards efficient utilization of resources poses formidable challenges. Major economic reforms gained momentum in India in early nineties, but it failed to deliver effectively due to the lack of appropriate implementation measures that were required to ensure sustainability. This necessitates adoption of strategies with 'equity, economic efficiency, environmental soundness, long-term viability, self-reliance and peace' for regional and nation's sustainable development.

In a rapidly urbanizing economy with fast technological changes, there is a need for governments to quickly and continuously ‘adapt’ to these changes through enabling technologies for ensuring a smooth and sustained workflow through interactions with the government and the people. Thus, the governance consists of the mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences. Poor governance generates and reinforces poverty and subverts efforts to reduce it. Good governance would ensure that developmental schemes reach all sections of the society and aid in enhancing the quality of life. Strengthening governance is an essential ingredient for eradicating poverty while promoting sustainable development. Implications of fragmented, un-ordinated and weak governance is evident from the present pathetic status of Bengaluru.

Rapid unplanned urbanization in Indian Cities has posed serious with the plethora of socio-ecological issues such as changes in micro-climate, enhanced greenhouse gases (GHG) emissions, depletion of groundwater resources, traffic congestion, inadequate infrastructure, poor basic amenities, etc. Bangalore once acclaimed as Silicon Valley of India is a classic example of victim of unprecedented rapid urbanisation and sprawl due to concentrated developmental activities with impetus on industrialization for the economic development of the region. This has led to large scale unrealistic land cover changes **during 1973 to 2016** with the strident increase (1005%) of paved surfaces, 88% decline in vegetation and 79% decline in wetlands. Prediction of land use during 2020 reveals that 93% of Bangalore landscape will be filled with buildings, etc. with severe consequences of water scarcity, pollutants, etc. making the city non-resilient and unlivable.

Wetlands (and lakes) constitute the most productive ecosystems with a wide array of goods and services. These ecosystems serve as life support systems; serve as habitat for a variety of organisms including migratory birds for food and shelter. They aid in bioremediation and hence aptly known as ‘kidneys of the landscape’. Water bodies constitute vital components of the regional hydrological cycle. Major services include flood control, wastewater treatment, arresting sediment load, drinking water, protein production, and more importantly recharging of aquifers apart from aiding as sinks and climate stabilizers. The wetlands provide a low cost way to treat the community’s wastewater, while simultaneously functioning as wild fauna sanctuary, with public access. These ecosystems are valuable for education and scientific endeavours due to rich biodiversity. They also enhance the aesthetics of the landscape and support many significant recreational, social, and cultural activities, aside from being a part of our cultural heritage. Most urban wetlands are being seriously threatened by conversion to non-wetland purposes, encroachment of drainage through landfilling, pollution (sustained inflow of untreated domestic and industrial effluents, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes), and overexploitation of their natural resources. This results in loss of biodiversity and disruption in goods and services provided by wetlands. These are highly productive ecosystems evident from the tangible benefits (fish, fodder, etc.) of Rs10500 per hectare/day at Rachenhalli Lake. This emphasises the need for wetland conservation to sustain water, food etc. in the region.

Good governance with sustainable management of regions with amazing potential to provide natural resources. Ecologically rich regions have to be protected and managed efficiently to sustain water, etc.

Western Ghats forms watershed for about 43 rivers and helps in sustaining water or water security. Our study reveals that, the sub basins with native forest cover (> 65%) had perennial streams, while sub basins with dominant monoculture plantations has seasonal streams (6-8 months depending on the extent of plantation cover) and sub-basins with degraded landscapes had streams which had water only for 4 months (that is only during monsoon). This emphasises the need for retaining native forest cover to sustain water in streams, which also gives food security.

Droughts in 278 districts or majority of districts in Karnataka further highlights the linkages of landscape cover and water availability. Current decision makers are not keen on conservation (as the revenue for them from the sustenance of natural resources are minimal). It is beneficial to the decision makers to destroy natural resources (under the mask of unrealistic 'development agenda'). After, degrading the ecosystem and come up with unrealistic projects (such as river diversion, etc.) would benefit the decision makers lobby (nexus of bureaucrats, contractors, engineers, etc.).

Our studies also reveal of interesting linkages of farmers suicide only in deteriorating landscape or regions which has undergone large scale transformation due to deforestation. We did not witness any suicide death in Western Ghats districts, while neighbouring districts with higher rate of deforestation or degraded landscapes saw large scale farmers' suicide due to (i) water scarcity, (ii) inappropriate cropping in drier districts, (iii) dependence on GM crops (at the mercy of MNC's and moneylenders) than native varieties and (iv) irresponsible politicians.

Further, villages in the downstream of perennial streams (forested landscapes) grow three crops (as well as horticulture crops) compared to villages in the downstream of degraded landscape. The revenue generation in these villages (with perennial streams) had revenue at least 5 times higher than villages in degraded landscape.

We need to have sensible development and currently the 'development' is hijacked by timber mafia, etc. As politicians and bureaucrats are benefitted by these sections of the society, everyone take refuge of 'development agenda' to loot natural resources.

Q) Environmental management is always on spotlight including community based natural resource management. Covering day to day basis of improving human welfare situations, how you see to maintain energy conservation and waste treatment. There are various bio-treatment plans. How much importance does it lay on implementation of plans?

Comment:

Well, there are many technically feasible, economically viable, socially acceptable and environmentally sound option. For example, the country's landscape is blessed with abundant solar energy and bioenergy in addition to ample youth power. We need to harvest renewable sources of energy in decentralised way would also help in addressing the energy scarcity while enhancing job opportunity to our youth. Our country will certainly be developed nation provided our current generation (decision makers, etc.) optimise renewable sources of energy along with youth. We need to be intelligent to tap these abundant resources.

We have discussed various aspects of energy in

- **Energy Trajectory in India: Challenges and Opportunities for Innovation**
<http://wgbis.ces.iisc.ernet.in/energy/paper/Energy-trajectory-in-India/index.html>
- **DECENTRALIZED RENEWABLE ENERGY OPTIONS FOR WESTERN GHATS**
<http://wgbis.ces.iisc.ernet.in/energy/paper/DECENTRALIZED-RENEWABLE-ENERGY-OPTIONS/index.html>
- Distributed Solar Energy Systems
<http://wgbis.ces.iisc.ernet.in/energy/paper/Distributed-Solar-Energy-Systems/index.html>
- Hotspots of solar potential in India
http://wgbis.ces.iisc.ernet.in/energy/paper/hotspots_solar_potential/index.htm

The implementation of generation based incentive schemes in Karnataka, rooftops are gradually transforming to energy generators in decentralised way (without incurring any T & D losses).

Development model proposed by us – empower rural India to stop migration and other related issues through 'SMART Villages'

SMART Ragihalli: Effort towards Self-reliant & Self-sufficient system empowering Man power (rural youth) with Appropriate Rural Technologies

https://www.researchgate.net/publication/281320307_SMART_Ragihalli_Effort_towards_Self-reliant_Self-sufficient_system_empowering_Man_power_rural_youth_with_Appropriate_Rural_Technologies

Regarding Waste:

Our studies reveal 72-75% is organic in household which constitute major fraction in Municipal solid waste. On an average each family generates about 800 to 900 gms of waste every day. This fraction can be converted to either energy or compost (if lignin content is high) through appropriate technologies. However, due to mismanagement organic fraction is getting mixed with other fractions posing serious challenges. Solutions are

- i. Segregation at source and collection of the segregated waste through authorised NGO or entrepreneur.

- ii. Introduction of **incentive based segregation** would help in ensuring the segregation at source. This entails (a) mobile waste van with partitions to collect segregated wastes, (b) incentive to those who segregate – let us pay Rs 1.50 per kg of segregated organic fraction (and payment to the respective household bank account linked with Aadhar), (c) penalty to those who do not comply segregation - disincentive of Rs 5 per kg of unsegregated waste (irresponsible household need to pay Rs 5 per kg if they are unwilling to segregate).
- iii. Decentralised treatment options – we need to set up waste collection and treatment at each wards. Energy generated be used for community canteens or street lamps (conversion to electricity through dual fuel engine)
- iv. Recovery of recyclables (which is about 20-24% of total waste)
- v. Only inert material should go to landfill site (so that there won't be leaching and subsequent pollution of land and water)

All these are possible only if we can break the current nexus of contractors, engineers and budding politicians (corporators!).

Q) Talking over waste treatment. There can be different kind of wastes. One such is waste water. You have an article on Waste water disposal. Can you provide a clear picture or brief idea over the waste water management? Water conservation is also an associated part, talking about mainly the natural resource – ‘Groundwater’ the current overlooked human behaviour hazards namely unwanted wastes, chemical containing storage tanks, landfills etc. have provided a threat. How much importance does it lie on groundwater management policies in India?

Comment: Yes, the day we start perceiving ‘waste’ as ‘wealth’, we will start managing these resources and there won’t be any waste problems. Bangalore generates about 1600 MLD (million litters every day). Waste generated in household is either treated partially or let into interconnected lake system through chain of storm water drains. Our forefathers created lakes/tanks/ponds taking advantage of undulating terrain. We have now about 93 water bodies and most of them are polluted with the sustained inflow of untreated sewage. This has contaminated groundwater resources in many parts of Bangalore. 45% of Bangalorean’s depend on ground water and contamination (higher nitrate, etc.) certainly poses serious health issues evident from water borne diseases, cancer, kidney failure, etc.

Latest field survey of 105 wetlands (Ramachandra et al., 2016) reveals that lakes (98%) have been encroached for illegal buildings (high raise apartment, commercial building, slums, etc.). Field survey of all lakes (in 2014-15) shows that nearly 90% of lakes are sewage fed, 38% surrounded by slums and 82% showed loss of catchment area. Also, lake catchments were used as dumping yards for either municipal solid waste or building debris. The surrounding of these lakes have illegal constructions of buildings and most of the times, slum dwellers occupy the adjoining areas. At many sites, water is used for washing and household activities and even fishing was observed at one of these sites. Multi-storied buildings have come up on some lake beds that have totally intervene the natural catchment flow leading to sharp decline and deteriorating quality of water bodies. Unauthorised construction in valley zones, lakebeds and rajakaluvus highlight the apathy of decision makers while revealing weak

and corrupt governance. This is correlated with the increase in concrete area (built up area, etc.), affecting severely open spaces and in particular water bodies. Other implications are:

- **Floods:** Conversion of wetlands to residential and commercial layouts has compounded the problem by removing the interconnectivities in an undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetative cover, reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post 2000.
- **Decline in groundwater table:** Studies reveal the removal of wetlands has led to the decline in water table. Water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of lake with its catchment for commercial activities. In addition, groundwater table in intensely urbanized area such as Whitefield, etc. has now dropped to 400 to 500m.
- **Higher levels of contaminants in groundwater:** At 400- 500 m natural geological strata contains trace elements, which means people who are using this water (available at 400- 500m) are exposed to regular consumption of water contaminated with heavy metals. Higher instance of kidney failure in Bangalore highlights the urgency to improve the situation through rain water harvesting and recharging groundwater resources. Bangalore receives about 700- 850 mm annual rainfall. Commutation of water yield in Bangalore catchment reveals that Bangalore landscape gets about 15 TMC (thousand million cubic feet) and the water demand in Bangalore is about 16-18 TMC, which means the water that is available in the form of precipitation meets more than 90% of demand.
- **Lakes and wetlands** play a pivotal role in groundwater recharge and harvesting of rainwater through lakes/wetlands is the best option to quench regions' water demand. However, sustained inflow of untreated sewage has enriched lakes with nutrients (N and P). This is transported to nearby underground water resources, evident from higher levels of nitrates in the groundwater resources. Nitrate being carcinogenic, consumption of nitrate rich water certainly will have serious health implications on the residents in close proximity to lakes. Details (Groundwater quality impairment due to mismanagement of biodegradable waste) available at http://wgbis.ces.iisc.ernet.in/energy/paper/ieee_biodegradable_waste/index.htm
Apart from this, untreated industrial effluents have enriched the lake water and sediments. This is being up-taken by vegetables grown in downstream. Higher levels of cadmium, chromium, copper, iron are found in the vegetables (leafy vegetables) and these vegetables are marketed in the city, making the entire population vulnerable to heavy metal contamination.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water pervious surfaces, which reduce surface temperature through evapotranspiration. . The study unravels the pattern of growth in Greater Bangalore and its implication on local climate (an increase of ~2 to 2.5 °C during the last decade) and also on the natural resources (78% decline in vegetation cover and 79% decline in water bodies), necessitating appropriate strategies for the sustainable management of natural resources.
- **Recurring episodes of large scale fish mortality:** Sustained inflow of untreated sewage has increased the organic content beyond the threshold of remediation capability. With the onset of summer, increasing temperature (of 34 to 35 °C) enhances the biological activities (evident from higher BOD and Ammonia) lowering dissolved oxygen levels, which has led to frequent large-scale fish death due to asphyxiation.

- **Increased carbon footprint:** Mismanagement of solid and liquid wastes has aggravated the situation. Dumping of solid and liquid waste to the lake has increased the anaerobic condition in the water body leading to emissions of greenhouse gases (methane, CO₂, etc.).

Conservation and Management of Wetlands: The loss of ecologically sensitive wetlands is due to the uncoordinated pattern of urban growth happening in Bangalore. This is due to a lack of good governance and decentralized administration evident from a lack of coordination among many para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for:

- **Restoring and conserving the actual source of water**—the water cycle and the natural ecosystems that support it—are the basis for sustainable water management.
- **Reducing the environmental degradation that is preventing in attaining the goals of** good public health, food security, and better livelihoods.
- **Improving the human quality of life** that can be achieved in ways while maintaining and enhancing environmental quality.
- **Reducing greenhouse gases to avoid the dangerous effects of climate change** is an integral part of protecting freshwater resources and ecosystems.

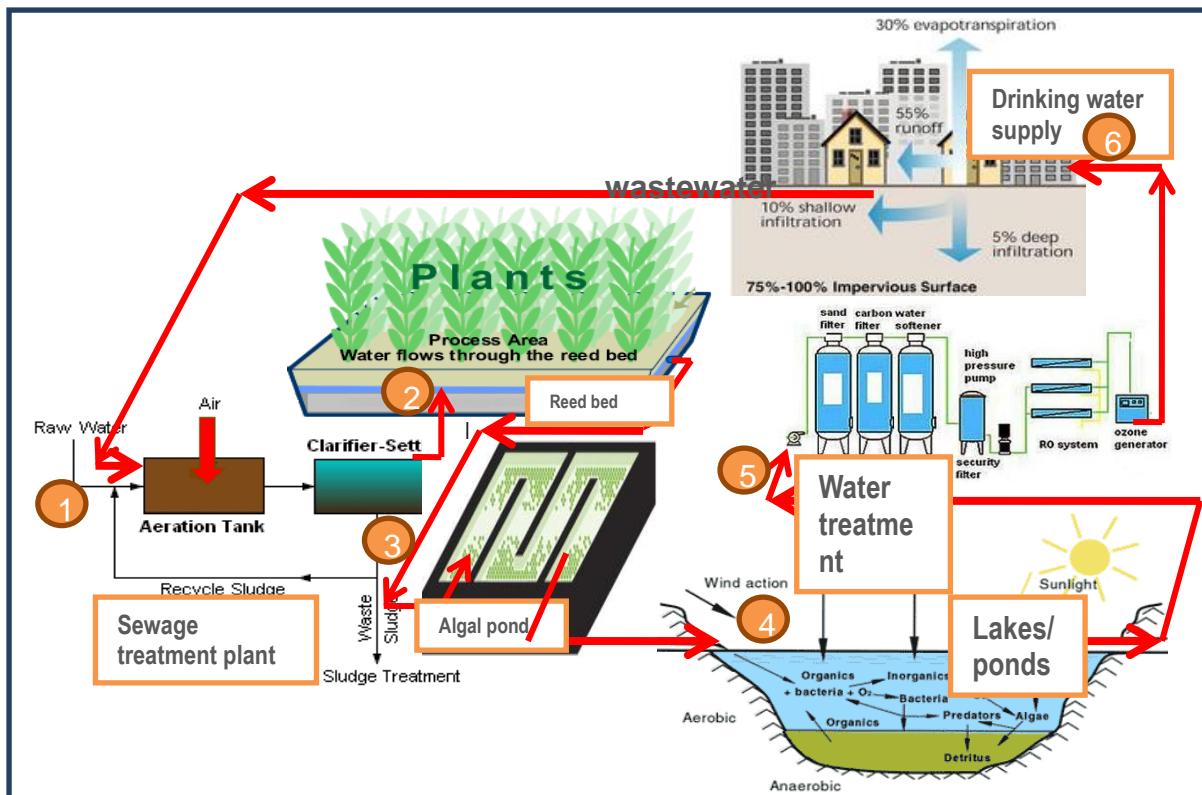
A comprehensive approach to water resource management is needed to address the myriad water quality problems that exist today from nonpoint and point sources as well as from catchment degradation. Watershed-based planning and resource management is a strategy for more-effective rejuvenation, protection and restoration of aquatic ecosystems and for protection of human health. In this regard, recommendations to improve the situation of the lakes are:

- **The need for good integrated governance systems in place** with a single agency with statutory and financial autonomy to act as the custodian of lakes for maintenance and action against polluters.
- **Effective judicial systems** for speedy disposal of conflicts related to encroachment
- **Access to information** for the public through digitisation of land records and availability of this geo-referenced data with query based information systems

Measures to clean and protect lakes

- Removal of encroachments from lakes, lake water beds and storm water drains, regular cleaning of lakes. We need to remove encroachments without any humanitarian considerations, as these individuals have unauthorised our common lands (lakes, parks, etc.) without anyone's permission. They need to pay for violating the norms of the land.
- Proper measures such as fencing to protect lakes and prevent solid waste from going into lakes
- Install water fountains (music fountains) which enhances the aesthetic value of the lake and also aid as recreation facility to IT professionals (working in IT sector in this locality) and elderly people. This also helps in enhancing oxygen levels through aeration.
- Introduce ducks (which helps in aeration)
- Introduces fish (surface, column and benthic dwellers) which helps in maintaining food chain in the aquatic ecosystem. This has to be done in consultation with fish experts.

- No exotic fish species introduction avoid commercial fish culturing (commercial fishery)
- Decentralised treatment of sewage and solid waste (preferably at ward levels). Sewage generated in a locality /ward is treated locally and letting only treated sewage into the lake (Integrated wetlands ecosystem as in **Jakkur lake**). Integrated wetlands system consists of sewage treatment plant, constructed wetlands (with location specific macrophytes) and algal pond integrated with a lake. Constructed wetland aid in water purification (nutrient, heavy metal and xenobiotics removal) and flood control through physical, chemical, and biological processes. When sewage is released into an environment containing macrophytes and algae a series of actions takes place. Through contact with biofilms, plant roots and rhizomes processes like nitrification, ammonification and plant uptake will decrease the nutrient level (nitrate and phosphates) in wastewater. Algae based lagoons treat wastewater by natural oxidative processes. Various zones in lagoons function equivalent to cascaded anaerobic lagoon, facultative aerated lagoons followed by maturation ponds. Microbes aid in the removal of nutrients and are influenced by wind, sunlight and other factors (Ramachandra et al., 2014). This model is working satisfactorily at Jakkur. The sewage treatment plant removes contaminants (evident from lower COD and BOD) and mineralises organic nutrients ($\text{NO}_3\text{-N}$, $\text{PO}_4^{3-}\text{-P}$) to inorganic constituents. Integration of the conventional treatment system with wetlands [consisting of reed bed, typha etc. and algal pond] would help in the complete removal of nutrients in the cost effective way. Four to five days of residence time in the lake helps in the removal of pathogen apart from nutrients. However, this requires regular maintenance through harvesting macrophytes and algae (from algal ponds). Harvested algae would have energy value, which could be used for biofuel production. The combined activity of algae and macrophytes helps in the removal of ~45% COD, ~66 % BOD, ~33 % $\text{NO}_3\text{-N}$ and ~40 % $\text{PO}_4^{3-}\text{-P}$. Jakkur lake acts as the final level of treatment that removes ~32 % COD, ~23% BOD, ~ 0.3 % $\text{NO}_3\text{-N}$ and ~34 % $\text{PO}_4^{3-}\text{-P}$. The lake water with a nominal effort of sunlight exposure and filtration would provide potable water. Replication of this model in rapidly urbanizing landscapes (such as Bangalore, Delhi, etc.) would help in meeting the water demand and also mitigating water scarcity through recharging of groundwater sources with remediation.



- **Better regulatory mechanisms** such as
 - To make land grabbing a cognizable, non bailable offence
 - Implementation of the polluter pay principle
 - Ban on construction activities in the valley zones
 - Restriction of diversion of the lakes for any other purposes
 - Decentralised treatment of sewage and solid waste and restriction for entry of untreated sewage into the lakes
- **Encouraging involvement of local communities:** Decentralised management of lakes through involvement of local communities in the formation of local lake committees involving all stakeholders.

Q) Let me give a small pause to our discussion on environmental management. You have been doing research in IISc Bangalore and have researched on Environment management and sustainability. What grade you will provide on 10 based on your visualization of Environment conservation in Bangalore as well as overall India.

Comment: 2/10 (I am disappointed with the lukewarm response of decision makers, for not taking suggestions based on scientific data in the decision making. Bangalore, despite being the hub of knowledge capital with numerous scientific and technology, very least input has been used in decision making and efforts to build sustainable city has failed due to arrogant bureaucracy and inefficient regulatory mechanisms)

Q) As we are talking about Bangalore I would be glad if you share your recent research on “Modelling Urban Revolution in greater Bangalore, India”. How much effort does

the team put to highlight such a scenario? What conclusion do you draw to overcome such issues in other parts of India or anywhere in near future?

Comment: Bangalore's unrealistic growth is an eye opener for any sensible Indian. Our next generation will pay heavy prices due to mistakes of the current generation. Proponents and individuals pushing the agenda of 'SMART CITIES' need to take valuable inputs of city (gradually transforming to unlivable city)

Bangalore is experiencing unprecedented rapid urbanization and sprawl in recent times due to concentrated developmental activities with impetus on industrialization for the economic development of the region. This **has led to large scale land cover changes with the serious environmental degradation**, posing serious challenges to the decision makers in the city planning and management process involving a plethora of serious challenges such as climate change, enhanced greenhouse gases (GHG) emissions, lack of appropriate infrastructure, traffic congestion, and lack of basic amenities (electricity, water, and sanitation) in many localities, etc. Urbanization during 1973 to 2016 (1005% concretization or paved surface increase) has telling influences on the natural resources such as decline in green spaces (88% decline in vegetation), wetlands (79% decline) and sharp decline in groundwater table. Fig. 2 highlights unrealistic urbanization during the last two decades. Quantification of number of trees in the region using higher spatial and spectral resolution remote sensing data with field census reveal 1.5 million trees and human population is 9.5 million, indicating one tree for every seven persons in the city. This is insufficient even to sequester respiratory carbon (ranges from 540-900 g per person per day). Geo-visualisation of land use during 2020 through multi-criteria decision making techniques (AHP: Analytical Hierarchical Process) reveals that 93% of Bangalore landscape will be filled with buildings, etc. This would make the region GHG rich, water scarce, non-resilient and unlivable, depriving the city dwellers of clean air, water and environment

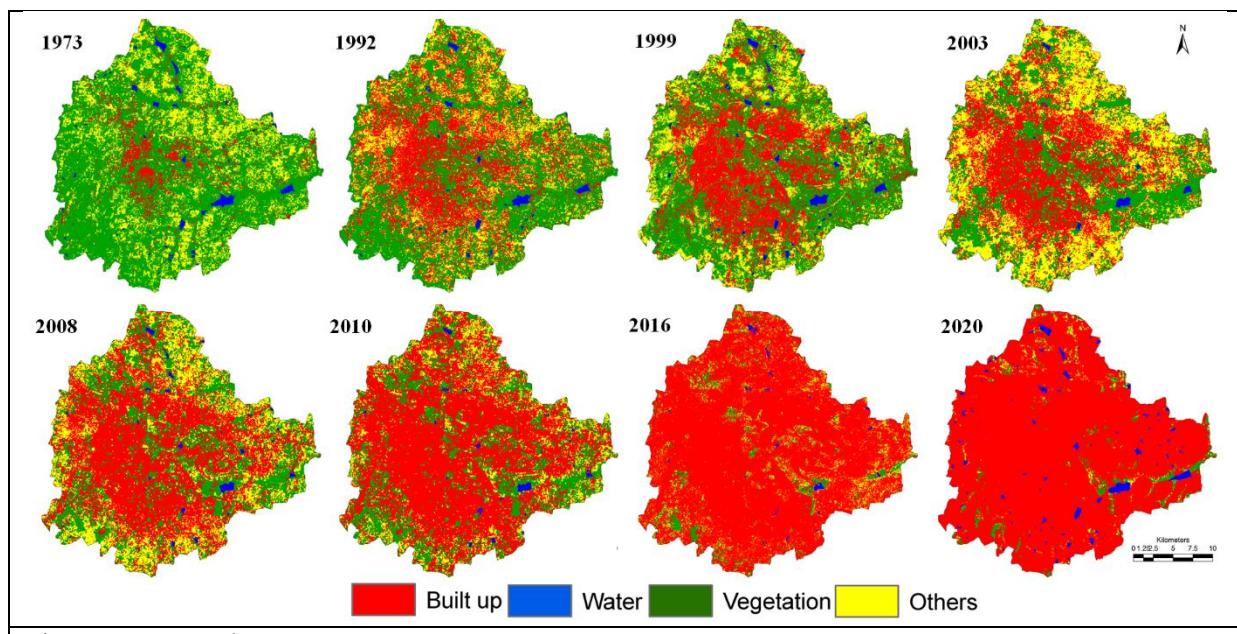


Figure 2: Bangalore's unrealistic urbanization during the last two decades

Q) You have constructed many bio-conservation models. Naming a few please allow us to know your best successful model. In near future what are your future plans?

Comment:

1. Mini forest in IISc campus: 500 saplings of 49 species from Western Ghats planted in 2 hectares area in late eighties, has transformed the landscape from scrub vegetation (with invasive species infestation) has transformed into rainforest (in midst of Bangalore's concrete jungle). Ground water in the region has improved from 150 feet (late 80's) to 10-15 feet (current groundwater table). Details at <http://www.iisc.ernet.in/> and at <http://wgbis.ces.iisc.ernet.in/energy/water/paper/researchpaper2.html#iisc> Temperature in this region is 2 degrees lower than IISc campus temperature (which is 2-3 degree lower than city temperature)
Habitat for diverse fauna – Slender Loris, diverse reptiles, birds...
2. Successful lake rejuvenation model (discussed earlier – Jakkur lake)
3. Creation of water body in the campus. Implemented in 2008, stores ten lakh litters of water every year.

<http://wgbis.ces.iisc.ernet.in/energy/water/paper/researchpaper2.html#iisc>

We have been successful in taking our learnings from nature to field through lab. Ability of vegetation and algae to uptake nutrients has helped in designing bioreactor and successful model is in the field.

Current research focusses on algae based biofuel (viable alternative to fossil fuels). Details at

<http://wgbis.ces.iisc.ernet.in/energy/paper/researchpaper.html#bio>

We are trying to understand the ecological processes and develop ecological models, which would help in conservation (with likely scenario's based on the current ongoing process), exploring cost effective ways for harvesting renewable sources, exploring sustainable sources of energy, environmentally sound urbanisation, smart villages,

Q) Research means idealizing your facts and implementing it as genius. You have done versatile research like on Ecological nice reservation, various sustainability models, animal conservations like fish, frogs, etc. ; on this behalf we would like to know how you set your goals in different point aspect. How you entertain your student researchers for environmental management and conservation research? Would you like to introduce us with your fellow students and their current goals?

Comment: This is the benefit of interdisciplinary research working with multidiscipline experts, youngsters, etc. Stalwart colleagues and students have helped in achieving the goals. As scientist with understanding of social responsibilities, our interaction with the stakeholders from society has also helped in diversifying our research domain. Our research

group's regular monthly meetings is the forum for knowledge acquisition of current status (deliberation of work progress) and newer ideas (presentation of recently published scientific communication). This has helped immensely every researcher in my group to embark on new and challenging tasks. Regular scientific interactions with young researchers always helps in setting our goals.

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<p>Dr. T.V. Ramachandra, FIE, FIEE(UK) obtained Ph.D. in Ecology and Energy from Indian Institute of Science. At present, Coordinator of Energy and Wetlands Research Group (EWRG), Convener of Environmental Information System (ENVIS) at Centre for Ecological Sciences (CES). During the past twenty years he has established an active school of research in the area of energy and environment (http://ces.iisc.ernet.in/energy). He is a member of Karnataka State Audit Advisory Committee (2014-16) and member of Karnataka State Pollution Control Board Technical committee (Biodiversity). He was a Member of Karnataka State level Environment Expert Appraisal Committee (2007-2010), appointed by the Ministry of Environment and Forests, Government of India and a member of Western Ghats task force appointed by the Government of Karnataka. He is a recipient of Energy Legend (2011, 2014), Energy Engineer (international, 2009) of Association of Energy Engineers (USA), Johny Biosphere Award for Ecology and Environment (2004), Satish Dhawan Young Scientist Award, 2007 of Karnataka State Government, ENVIS Award (2004, 2014), The Ministry of Environment, Forests and Climate Change, GoI.</p> <p>He is an <i>Elected Fellow</i> of the Institution of Electrical Engineers (IEE, UK; 2005), Indian Association of Hydrologists (India; 2006), Institution of Engineers (IE, India; 2003), and a Senior Member, IEEE (USA; 2000) and Association of Energy Engineers (USA; 2000), National Institute of Ecology (2011).</p> <p>TVR's research interests are in the area of aquatic ecosystems, biodiversity, ecological modeling, Western Ghats ecology, energy systems, renewable energy, energy conservation, energy planning, geo-informatics, environmental engineering education research and curriculum development at the tertiary level. He has published over 248 research papers in reputed peer reviewed international and national journals, 49 book chapters, 228 papers in the international and national symposiums as well as 15 books. In addition, he has delivered a number of plenary lectures at national and international conferences. Publication "Milking diatoms for energy" is seminal work in biofuel research evident from reports in Scientific American, BBC, national dailies, etc.</p> <p>He has guided 108 students for Master's dissertation and nine students for Doctoral degrees. TVR has travelled widely across the country for field research and also for delivering lectures at Schools and Colleges. He has taken initiatives through biennial symposium (popular as Lake series), training programmes and workshops for capacity building at various levels. Next event, Lake 2016 - Tenth biennial lake symposium is scheduled during 28-30 Dec 2016 at Mudbidri, Karnataka</p> <p>Publications are available at https://www.researchgate.net/profile/T_V_Ramachandra/publications</p>	

Q) Let me put forward you a question as a general non-scientific person. We often have seen various Environmental Dooms day been focused highlighting big Tsunamis as seen in “2012 The film” and also as ice age was shown to come back in film “Day after tomorrow”. How much truth does it focus? If you call them you won’t believe in such theories then does one time natural calamities will bring the end of habitat?

Comment: These certainly aid in cautioning the system apart from acting as warning signals, one has to take seriously to come up with appropriate mitigation and restoration measures. If we continue to abuse mother Earth, dooms day is certain. Disappearance of pollinators due to excess use of insecticide, pesticide, etc. points towards food insecurity. Deforestation will accelerate global warming and lead to large scale changes in the climate.

Q) It is really wonderful to present lots of questions in front of you. As we bring this interview into short. What suggestions would you provide for general people about Environment?

Comment: Let us be sensible and responsible and make our mother Earth proud with planned strategies to meet the needs of the society.

Q) We know you as scientific researcher, role model as Environmentalist, and also wide scientific communicator. Apart from scientific life we would like to know your life apart from science.

Comment: Science is an integral part of my life, research for 14 – 16 hours every day for the last two and half decades, has helped in unravelling interesting facts (energy, ecology, hydrology, biodiversity linkages). Scientific discussions with my group members, advocacy and regular scientific lectures at schools and colleges has kept all of us healthy and wealthy. This has been possible due to sustained support of all members in the family and my young students, wonderful colleagues and well-wishers throughout the country and abroad. Achievements were possible due to true academic freedom at my organisation (Indian Institute of Science). Wonderful environment (with lush green cover) in my campus and also in field, knowledgeable colleagues and ever inquisitive students always helps sincere researchers. All my publications are archived at

<http://wgbis.ces.iisc.ernet.in/energy/>

https://www.researchgate.net/profile/T_V_Ramachandra/publications

Q) Thanks a lot Dr. T. V. Ramachandra for your wonderful words you presented for the audience. As we end would like to spare some word for well known monthly scientific magazine “Science Reporter”?

Comment: Thank you. Let us communicate effectively tenets of science, taking advantages of technological advances and make every child in India responsible and knowledgeable so that

our motherland benefits from the immense knowledge of the responsible youth force (who constitute major fraction of our society).

Thank you. Please mail me if you have questions in between. Feel free to answer them.

Best Regards

On behalf of Science Reporter,

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