

Current Science Reports

Land Use and Land Cover Changes

Predicting Surat's future

City infrastructure, such as bridges, flyovers and buildings, trap heat. Urban land use and land cover, when mismanaged, leads to the formation of heat islands. Satellite imagery has been a primary data source to assess temporal changes in land cover and land use. Using models, it is possible to foresee the future dynamics of urbanisation.

P. R. C. Prasad, International Institute of Information Technology, Hyderabad joined hands with researchers from BML Munjal University, Haryana to predict future urbanisation scenarios in Surat.

They took satellite image data from Landsat 5, 7 and 8 and used geographic information system software to generate land use and land cover maps for 1990, 2001, 2009 and 2020.

Using an image analyst, they generated samples from different classes such as built-up areas, vegetation, water bodies, barren land, aquaculture farms and dry river beds. With the help of a maximum likelihood algorithm, the satellite images were classified into various land cover classes.

The team also correlated how vegetation impacts land surface temperature. Land surface temperature was calculated for the same years using a mono window algorithm in which elements like the capacity to emit radiation, transmitted radiation and increase in average temperature due to the greenhouse effect were extracted.

The team used a Markov model to predict future changes in land use and land cover. The model uses a random probability distribution where it is assumed that future states do not depend on past states.

A multi-layer perceptron was trained with different land use driver factors like slope, distance from roads, man-made areas and water bodies. Due to the limitation of a smaller study area, appropriate spatial trends between different classes were used.

Vegetation in Surat had decreased by 42 square kilometres since 1990 and built-up area had increased by 94 square kilometres. By 2030, the team predicts

that built-up area in Surat will increase by 283% and vegetation will decrease by 45%.

What can be done to save the city?

'Citizens need to be included in policy making on urban development and urban planners have to raise awareness about the need to develop greenery,' advises P. R. C. Prasad, International Institute of Information Technology, Hyderabad.

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Saline Intrusion in Vembanad Lake

River to the rescue

Vembanad Lake forms the heart of the Kerala backwaters. During the monsoon, the rivers carry freshwater to the estuarine lake system and aid paddy cultivation. In the other seasons, the rivers dry up. Seawater makes its way to low-lying areas and hampers paddy productivity. To address this, the Thanneermukkom Barrage was constructed in 1974.



Image: Brendanpuck via Wikimedia Commons

The bund, however, affected the natural flow of water. Stagnant water has been accumulating various pollutants. And paddy cultivation and fish population have reduced drastically.

K. R. Muraleedharan from the CSIR-National Institute of Oceanography, Kochi and researchers from Bharathidasan University, Tiruchirappalli collaborated to determine the ideal river discharge to prevent saline intrusion. They used a hydrodynamic model – the Finite Volume Community Ocean Model – to simulate tides, currents and salinity patterns in Vembanad Lake.

Using water level recorders and profilers, the team monitored the tides, currents and salinity for a month at six locations. They used this information for validating and fine tuning the model and applied it to maps using geographic information software.

The team found that salinity changed on a daily, weekly and monthly basis. The salinity of the lake greatly depended on the river discharge, followed by tides.

Model simulations showed that Vembanad Lake becomes a freshwater body during the monsoon, and a stratified, mixed water body in the other seasons. Pre-monsoon, the maximum salt intrusion was till the Thanneermukkom Barrage, 45 kilometres inland, which reduced drastically to 15 kilometres during the monsoon.

Numerical experiments showed that a cumulative freshwater discharge of 20 cubic metres per second is enough to prevent saline intrusion into the lake system.

'Flushing can minimise further damage to the lake ecosystem,' says K. R. Muraleedharan.

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Patterns in Plant Phenology

What do they indicate?

Plants exhibit seasonal traits such as leaf emergence, flowering, fruiting and ageing of leaves. In order to acclimatise to changes in temperature or precipitation, plants adjust the onset of these traits. These variations generally affect all members of a species equally.

Recently, a team of twenty-three researchers, including Manzoor A. Shah from the University of Kashmir, carried out an elaborate study to estimate the variations and their impact on plants.

Under natural environment, across five botanical gardens, the team monitored over 200 herbaceous species via a global network of botanical gardens initiative, PhenObs. The scientists recorded various plant traits on a weekly basis: plant height, leaf size, seed mass, and so on. They also observed growth, leaf unfolding and senescence, flowering and fruiting.

The researchers analysed the data and found strong correlations between several traits and phenology. They found that plant height was a significant feature. The shorter varieties were more likely to leaf out earlier.

The researchers also noticed a negative correlation between leaf size and

duration of flowering and fruiting. Heavier seed mass led to shorter flowering duration. Early onset of growth led to early leafing. Early flowering led to early fruiting, and so on. However, early onset also led to early cessation of flowering or fruiting. The team did not observe any increased duration of any trait.

'Our study provides new insights into the relative importance of species relatedness for determining phenology,' claims Manzoor A. Shah.

The team speculates that larger leaved plants may outcompete early flowering smaller species. Botanists can use this information to study phenological variations and the influence of micro environments in more plants. Citizen science initiatives and participation may help monitor these changes at a much larger scale.

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Farm to Plate Strategy Potato post-harvest loss

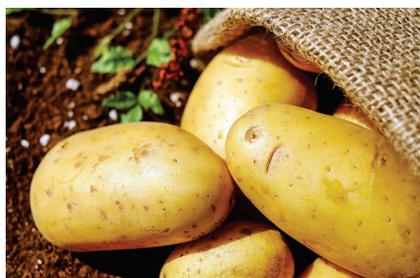


Image: Coulouer via Wikimedia Commons

Post-harvest loss of potatoes is influenced by soil and weather conditions during growth, harvest and storage. Many studies have estimated farm-to-plate losses. However, most of the research was subjective. And the analyses were based on surveys that only tackled narrow areas.

Brajesh Singh, ICAR-Shimla, along with colleagues from ICAR, Punjab grew two potato varieties, K Chipsona-1 and K Pukhraj, at ICAR research fields in Punjab.

After harvesting the potatoes by hand, the team heap stored both varieties for 5, 10, 15 and 20 days, stacking them to a maximum height of one metre and covering them with one foot thick wheat/ rice straw or sugarcane trash.

Before subjecting the tubers to cold storage treatments, they calculated any loss due to sprouting and weight loss

due to moisture evaporation during heap storage.

Then, some tubers were kept for 3 months at 2–4°C with no treatment. Others were treated with a sprout inhibitor, isopropyl N-(3-chlorophenyl)-carbamate, at a dose of 20 milligrams per kilogram and kept for 3 months in non-refrigerated conditions between 10°C and 12°C.

The tubers lost weight under cold storage due to sprouting which increases moisture permeability a hundred folds. K Pukhraj had higher losses due to evapotranspiration than K Chipsona.

The team calculated initial and final weights for two consecutive years. Losses were lower at field level than in heap storage and marketing chains.

Under low temperatures such as 2–4°C, the starch in potatoes is converted into sugar. The sweet taste is not liked by consumers.

'To avoid losses at both harvest and post-harvest, potatoes should be harvested at their peak maturity. Losses during harvest are due to small unpicked tubers,' explains Brajesh Singh, ICAR-Shimla.

Farmers and potato traders could store potatoes at 10–12°C rather than in heaps or at 2–4°C to reduce losses. And householders could store potatoes with apples. The ethylene gas emitted by apples prevents potatoes from sprouting.

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Probiotic Supplementation In polycystic ovarian syndrome

Polycystic ovarian syndrome is a hormonal disorder. It affects metabolic and reproductive functions. It is treated with hormones. Lifestyle changes and dietary changes are also advised. However, hormonal treatments have side effects.

Gut microbiota are known to influence many bodily functions. Dysbiosis of gut microbiota is common in women with polycystic ovarian syndrome. Could the combined use of probiotics and lifestyle modifications without hormones bring relief?

To investigate, Ishwarpreet Kaur and co-workers from the Post Graduate Institute of Medical Education and Research, Chandigarh, in collaboration with

Unique Biotech Limited, Hyderabad, conducted a clinical trial. They recruited about a hundred females with polycystic ovarian syndrome. Half of them were given a probiotic formulation and the other half a placebo, maltodextrin.

The treatment group was given an oral probiotic capsule with ten billion colony-forming units of bacteria belonging to the *Lactobacillus* species, *Bifidobacterium bifidum* and a prebiotic plant-based fructo-oligosaccharide once a day for two months, followed by twice a day for four months. All participants received diet and exercise plans. And social media was used for keeping the women motivated to follow the advice. The investigators recorded the results after follow-up visits every month.

They analysed the outcomes using the intention-to-treat method where all participants irrespective of treatment are included in statistical analyses and the per-protocol method which includes only patients who received treatment. All the participants were considered for the intention-to-treat analysis.

Drop out rate was minimal. Forty-eight were considered in the probiotic group and 49 in the placebo group for the per-protocol method.

The researchers recorded the primary outcome as regularity in the menstrual cycle. The secondary outcome was levels of blood sugar and various hormones such as testosterone, follicular stimulating hormone, luteinizing hormone, insulin and dehydroepiandrosterone.

Using a questionnaire, the team documented quality of life, body mass index and measured waist to hip ratio and circumference.

At the end of the trial, they observed a significant improvement in the menstrual cycle in more than 30% of the women in the probiotic group compared to what they found in the placebo group. Women in this group also had reduced testosterone levels, waist to hip ratio, waist to hip circumference and body mass index.

The researchers encourage gynaecologists, endocrinologists and dieticians to prescribe probiotic supplements along with lifestyle modifications to manage polycystic ovarian syndrome. However, more clinical investigation is required.

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Estimating Foetal Heart Rate

Using improved algorithms

Foetal heart rate can be measured using phonocardiography, a simple and non-invasive method. A phonocardiograph detects and records sounds made by foetal cardiac structures and moving blood, from the abdomen of pregnant women. But foetal heart signals are feeble because a part of the signal is absorbed by intervening tissue. Moreover, the signal-to-noise ratio is low.

Noise from internal factors, such as foetal movement and other abdominal sounds, as well as interference from the clinical environment, power supply and electronic devices make it difficult to extract heart rate signals from recordings.

How can we improve the signal processing to extract more accurate foetal heart sounds?

Recently, Amrutha Bhaskaran and her colleagues from IISc Bengaluru tried to improve signal quality. They collected foetal phonograph recordings of 99 expectant mothers from St John's Hospital, Bengaluru over a period of one year.

Records obtained by using the main power supply were noisy. So the team powered the instruments with battery backup. Ambient noise was measured using a sound level meter.

The researchers filtered the records. Sixty were of acceptable quality. From these records, the researchers marked peak heart sounds manually to get a reference.

To extract foetal heart rate from the recording, they used a Hilbert transform to detect the envelope of the signal. Then, they applied autocorrelation to separate periodic sounds from the noise.

The team compared the extracted signals with reference data. To check the accuracy of the detected peak sounds in the signal, they included a validation step in the algorithm.

'Our algorithm improved the measurements when combined with peak validation steps,' says Manish Arora, IISc Bengaluru.

The findings might benefit manufacturers to improve the sensitivity of foetal heart rate monitoring devices by incorporating better algorithms.

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Intrapartum and Postpartum Care

Quality improvement initiative

India's current maternal and neonatal mortality rate has a long way to go to catch up with the global goal. The main reason is the suboptimal quality of maternity care. Compared to the other states, Rajasthan has a higher newborn mortality rate – more than 1500 per lakh live births. Could interventions improve intrapartum and immediate postpartum care in the state?

Since 2015, the Ministry of Health has been implementing Dakshata, a capacity-building programme for healthcare providers, at public sector health facilities in various states of India.

Recently, researchers assessed Dakshata's impact on health care practices in Rajasthan. The programme has essential steps like stakeholder's sensitisation, rapid assessment of facilities, training master trainers, training healthcare providers, mentorship programmes and periodic assessments. The administrators initially ran a programme of stakeholder sensitisation for a half day to promote public acceptance. They also conducted a rapid baseline evaluation of the facilities.

Training master trainers, experts in the medical field, was the next task. A three- to five-day course covered managing labour and its complications.

The master trainers then trained about 4000 others from various public institutions in Rajasthan. When each centre was saturated with trainers, mentorship was initiated at other facilities to transfer the knowledge.

Obstetric simulation drills for managing the third stage of labour and maternal and new-born problems were part of the training.

Along with the training, labour room standards were raised and necessary materials were made available. All documents were in digital format. To help with clinical decisions, Labour Watch, an Android app, was introduced along with Mentor Watch, a training aid for the Android app users.

At six-month intervals, there were evaluations of the entire programme using the same instrument.

The team now examined the entire process and made suitable corrections. They analysed the data about the pro-

gramme from facility assessments, service statistics and monthly progress reports. This covered 202 public facilities in 20 districts of Rajasthan with baseline data from June–August 2015 and current information from May to August 2019.

The main difficulties encountered during the programme were staff shortages, a rise in staff turnover, inaccurate data recording, a large number of facility owners and poor adherence to essential practices like hand hygiene, plotting partographs, new-born resuscitation, post neonatal monitoring and counselling.

The Dakshata initiative improved the quality of mother and new-born care during labour and after delivery in Rajasthan. There was a significant decrease in complications like postpartum haemorrhage, neonatal hypoxia and stillbirth among women and babies. To lower the rate of maternal and new-born deaths, the government should expand the quality initiative to other Indian states.

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Detecting Pesticides in Food

Smartphone-integrated paper sensor

Dimethoate is a commonly used organophosphorus pesticide used in agriculture. Dimethoate residue in vegetables can be toxic to humans. Testing for the residue is complex and costly.

Recently, researchers from the Nagarjuna Post Graduate College of Science and the Pt Ravishankar Shukla University, Raipur collaborated with colleagues at the Guru Ghasidas Vishwa-vidyalaya, Bilaspur and came up with a simple, low-cost method.

When copper–silver nanoparticles are mixed with dimethoate, the mixture turns yellow to reddish yellow due to the aggregation of the silver nanoparticles. The researchers used this principle to design a paper sensor. They synthesised copper–silver nanoparticles and stabilised them with citrate ions to prevent the nanoparticles from aggregating.

Using a micropipette, the researchers filled a clean inkjet printer cartridge with aqueous solutions of the copper–silver nanoparticles. And they imprinted circles of the nanoparticles on Whatman filter paper numbers 1, 41 and 42 and

on normal paper to test which was the best paper for the purpose.

From a local market, the team bought some vegetables and ground them into fine particles. The ground particles were filtered and made into a solution. The solution was spiked with different concentrations of dimethoate. The researchers then dropped the solution on the nanoparticles printed on paper. The dimethoate in the solution replaced the citrate ions because of its higher affinity to silver nanoparticles and the nanoparticles aggregated to change colour. The paper turned reddish yellow. Whatman filter 1 provided good colour intensity.

The researchers used a smartphone to capture the image of the paper strip in the presence of an LED flashlight. A colour detector app extracted red, green and blue values from the image, helping estimate the quantity of dimethoate. The team tried different brands of smartphones. All of them worked equally well.

They calibrated the colour changes in the paper sensor. The colour was optimum when the pH of the nanoparticles and the pesticides was between 3.0 and 5.0.

Food safety enforcement authorities can use this low-cost sensor to detect levels of dimethoate residue in vegetables and other food materials.

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Predicting Taxi Demand

Using machine learning

Taxi service is imbalanced in cities. In some areas, passengers wait too long,

while, in others, many taxis roam without passengers. How can we forecast taxi demand in a city based on past data to distribute rides in an effective way?

Akshata Gangrade and her colleagues from MANIT, Bhopal studied taxi demand patterns using digital data generated from GPS and smartphones.

They built several prediction models based on machine learning. To train the models, the group collected taxi-trip records from Chicago city for four years, 2016 to 2019. They wanted to visualise the spatiotemporal distribution of the taxis. So they aggregated daily hourly data into hourly, weekly, monthly and yearly trends. The researchers found that the demand for taxis was higher during working hours than at other times of the day. Similarly, the demand was different for weekdays and weekends, which then translates to monthly and even seasonal variations.

But the initial simulations did not agree with the actual data. The researchers realised that the model needed tweaking.

They added sociodemographic data from the 2010 census of seventy-seven community areas in Chicago. As can be expected, people from affluent areas with higher per capita income tended to favour taxis, whereas people from lower per capita income zones took public transport. Proximity to metro and bus stations affected taxi use in the area.

There is a higher flux of taxis in hotspots such as educational institutes,

medical facilities and recreational centres. So the researchers collected location-based data to further train their machine learning models. Based on the distribution of taxis, sociodemographic factors and city hotspots, they tested the models.

First, they tested the three data points separately and then combined them into a covariate model, which combines all the input variables.

The more the team fed data into the prediction algorithm, the more accurate its results became. And, since there were many input variables, multiple regression models performed better than linear models to correlate a relationship between the variables. Finally, the researchers projected the past taxi data for future taxi needs into a time-series dataset.

Understanding these patterns of taxis and consumer needs will help algorithms allocate the resources. And, though the study is based on Chicago, such research can be translated to a city like Mumbai, which is roughly the same size and overburdened with taxi demand.

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