also found to decrease. Upon UV-irradiation, a set of H\textsubscript{2}AuCl\textsubscript{4} solutions in TX-100 micelle did not change their respective conductance values with the addition of NaCl (10\textsuperscript{-2} mol dm\textsuperscript{-3}) solution. This is due to the binding of free chloride ions in the micelle. This is the reason that addition of NaCl in the vessel of gold nanoparticles did not change the conductivity. The effect of addition of NaCl and NaCN is shown in Figure 7.

This is a simple depiction of the macroscopic property of nanoparticles. The observation helps authenticate the formation of gold nanoparticles in the micellar medium by conductometry supported through plasmon absorption measurements. The stepwise evolution of Au(0) could be determined from the photoactivation process. The adsorption of ions onto the particle surface and the reaction, i.e. dissolution in particular, under ambient condition are demonstrated.

13. Acid dissociation of a surfactant molecule becomes less pronounced above its CMC value due to micelle formation and the micellar aggregates lowers the possibility of dissociation due to association effect (Bumton, C. A., private comm.),


ACKNOWLEDGEMENTS. S.K.G. and S.K. are grateful to the Department of Science and Technology, New Delhi for financial support. M.M. thanks Council of Scientific and Industrial Research, New Delhi for financial assistance.

Received 16 October 2002; revised accepted 30 December 2002

Assessment of changes in water-hyacinth coverage of water bodies in northern part of Bangalore city using temporal remote sensing data

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Indian Remote Sensing Satellite (IRSS) LISS-II and III images of different years/seasons (1988–2001) were used to compare the water-covered areas and the water hyacinth-covered areas of six water bodies (Doddabommasandra, Yelahanka, Jakkur, Rachenahalli, Nagavara and Hebbal) in and around the northern parts of Bangalore city, Karnataka, India, giving the exact areas under hyacinth cover. The findings showed that the area under water-hyacinth cover has increased in recent times compared with previous years. One possible reason for this is the pollutants being let into the water body, having excess nutrients which are absorbed by water hyacinth thus increasing the area under cover. The growth of water hyacinth is

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directly related to the nutrients like phosphates, nitrates, etc. which are mainly from agricultural run-off, sewage and industrial effluents. This would give an idea of the human activity in the catchment of the water body. The water area has thus reduced/decreased during the years, which has led to considerable depletion of its levels. The area of water body is mapped using satellite data and compared with actual area as indicated by the map of 1974. Recent field studies showed pollution levels to be generally high with ammonical nitrogen, alkalinity, increase in biochemical oxygen demand, chemical oxygen demand, sodium, iron, calcium, and total solids favouring robust growth of water hyacinth. These parameters are important for understanding the issues of management of freshwater resources. Monitoring the temporal changes in water hyacinth would be useful to understand the dynamics of a weed and its ecology as the ‘most successful colonizer’.

The aquatic weed, water hyacinth (Eichhornia crassipes (Mart.) Solms. Lauchb: Pontederiaceae) is an erect, free-floating, stoloniferous, perennial herb. It grows to 1 m in height with buoyant leaves, which vary in size according to growth conditions. One of the most successful colonizers in the plant world, the water hyacinth has spread within a hundred years from its home base in Brazil to at least fifty countries around the globe, including India.

Besides being bio-indicators of pollution, they efficiently remove mineral from the sediment nutrient pool and thus help in pollution abatement, by acting as nutrient pumps and serving as biological sinks.

Several studies in the laboratory as well as in the field have shown that water hyacinth reduces quantities of suspended particles, algae, dissolved impurities, nitrogen, phosphorus and other nutrients, redox potential, biochemical oxygen demand (BOD) and chemical oxygen demand (COD), turbidity, faecal coliform bacteria and organic carbon content1. Water hyacinth also absorbs and accumulates a large number of heavy metals (copper, cadmium, nickel, silver, chromium, iron, manganese, cobalt, strontium, lead, mercury, potassium, arsenic) and organic pollutants (phenols, dyes, diphenamid dyes, photographic pollutants)3.

Generally, water hyacinth propagates and multiplies vegetatively; vegetative propagation is rapid. Two plants of water hyacinth could multiply to 120,000 in 120 days, while thirty offspring could be produced from two parent plants within 23 days5. There is a high rate of water loss due to evapo-transpiration through its luxuriant growth with a rainfall of 900 mm, indicating the climate condition in Bangalore4.

Water hyacinth is well known for its ability to lose water rapidly through its leaves through transpiration. Thus the plant appears to derive its Hindi name ‘samudra sokh’ – which can absorb an ocean. In India, only 26% more water loss was observed through Eichhornia cover. The water loss is 7.76 ± 1.36 times higher in different seasons5. The evapo-transpiration rate from water-hyacinth cover is high. It is also demonstrated that the transpiration is directly related to temperature, nutrient uptake and vapour-pressure deficit resulting in heavy water loss8. In USA, water loss in irrigation channels has been estimated to be 2425 billion m³, valued at US $39.3 million every year. It was established that water hyacinth transpires water at a rate of 51 m²·day⁻¹ for 11.2 m²·amphistomatic leaf area². The evapo-transpiration rate is reported to be two to eight times more than the evaporation from a free water surface8. The disadvantage of water hyacinth was its alarming multiplication rates.

The rate of organic-matter production by water hyacinth is so high that the dead organic matter accumulates in the water body. The rate of decomposition of dead plants depends on the water quality10.

The hyacinth gets nutrients from minerals dissolved in the water, the principal nutrients being nitrates, phosphates and potassium, which are available as pesticides from agricultural run-off, sewage and industrial effluent. Agricultural run-off also has inorganic fertilizers and some amount of silt (from the catchment) in addition to pesticides, and thus contributes to inorganic and organo-metallic compounds.

Excess water-hyacinth growth has led to loss of water in water bodies devoid of oxygen, leading to dystrophic water bodies.

In the present study an attempt has been made to use satellite remote-sensing images to map the area of water body covered by water hyacinth over the years in Bangalore city.

The study carried out for an urban tank watershed (Mattikere tank in Bangalore city) shows that the urban area has increased more than two times in 13 years (240 ha in 1983 and 543 ha in 1996) at the cost of agricultural/open/scrub lands, which has reduced from 400 to 67 ha during the same time period. About 60% of water area has reduced and the dry tank seen in 1983, is currently occupied by hyacinth. Majority of the tank watersheds in and around Bangalore, face similar problems. So proper care needs to be taken to maintain the watersheds within the periphery as well as within urban areas. Otherwise such tanks will be lost and damage to the environment will be irrecoverable11.

Out of 298 tanks in and around Bangalore (as found during 1970–74), 112 have undergone changes due to urbanization12 – construction, waste disposal, playgrounds, bus stops, parks, etc. Changes in the water environment like the quality, water-holding capacity, number of water bodies, etc. are directly or indirectly due to activities such as industrialization, urbanization, etc.

Data after remote sensing are used for delineation of water-spread area and water hyacinth-spread area in a
water body. Various parts of the electromagnetic spectrum like visible, near infrared, thermal infrared and microwave are used in remote sensing to collect information on objects from aerial/satellite platforms. The various application studies carried out in India and elsewhere in the world prove beyond doubt that remote sensing is a powerful tool for the mapping/inventorying, monitoring and managing of natural resources due to the inherent advantages of synoptic viewing, repetitive imaging, capability to study inaccessible areas, relatively low cost and real time availability of data.

Due to the strong contrast between water and surrounding land surface afforded by satellite reflective infrared observations, mapping and monitoring of surface-water spread of lakes and reservoirs can be obtained with a good degree of accuracy. Using multivariate imagery of IRS, SPOT and Landsat data, the surface-water bodies can be effectively monitored. It is also possible to estimate the volume of water for any observed spread from satellite imagery.

The integrated information derived from the satellite data set assists in evolution of appropriate action plans for initiating sustainable development. The advent of microwave remote sensing has provided another quantum jump in remote sensing capability due to its ability to provide data during cloudy days/night and depth-penetration capability.

Exotic plant infestations impair water quality, impede water flow, disrupt fisheries, displace native plant species and reduce biological diversity.

Researchers have recently developed a digital video imaging system that stimulates Landsat Thematic Mapper’s mid infrared, near infrared and visible red bands, providing detailed resolution for interpreting satellite data/imagery. Scientists are detecting and mapping weed infestations in Lower Rio Grande waterways, including the river itself13.

The satellite remote sensing can enable scientists to monitor large areas rather quickly and efficiently and observe areas that are difficult to reach from the ground. The Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) instrument on NASA’s Terra satellite, for example, can view a roughly 60 km square area at a resolution of up to 15 m per pixel. Higher-resolution remote sensing imagery can also be acquired by commercial satellites, such as Space Imaging’s IKONOS satellite, which views a much smaller area than ASTER but has 1 m spatial resolution. Instruments on an aircraft may also play an important role in tracking plant infestations, as the aircraft can allow scientists to collect high-resolution images while frequently revisiting any given location of interest14.

Such remote-sensing instruments are used to track down hyacinths and other infestation. The ASTER images demonstrate the potential of remote sensing to monitor outbreaks. The first image was acquired on 30 March 2002, and the second image on 9 May 2002. In the near-infrared region of the spectrum, photosynthetically active vegetation is highly reflective. Consequently, vegetation appears bright to the near-infrared sensors aboard ASTER, and water, which absorbs near-infrared radiation, appears dark. In the false-colour images produced from the sensor data, healthy vegetation is shown as bright red while water is in blue or black. A water hyacinth infestation is apparent on 30 March near the centre of the image. By 9 May, the hyacinth population has exploded to cover over half the river in the scene.

Satellite images of Bangalore city and surrounding areas on 1:50,000 scale were used to map six lakes/water bodies (Doddabommasandra, Yelahanka, Jakkur, Rachenahalli, Nagavana and Hebbal) in the northern part of Bangalore city (Figure 1).

Satellite images of the six water bodies taken at different time intervals (Figures 1 and 2) were used to obtain the actual area of the water bodies during different periods and over the years. The tanks covered under the study fall within the Nagavana tank watershed (around 200 km²).

Indian Remote Sensing Satellite (IRS) Linear Imaging Self-Scanning System (LISS)-II and III images have been used in this study, LISS-II has 36 m and LISS-III 23 m spatial resolution. The Geocoded False Colour Composites are used in the study. The water bodies and water hyacinth have typical image signature (blue/black colours, smooth texture, tapering shape for water and bright red with smooth texture for hyacinth). Thus IRS LISS-II and III images were used for assessing the status of water spread in water bodies/lakes and the extent of water hyacinth. An attempt has been made to map and record the current status of water bodies with water hyacinth cover and without water hyacinth cover, and the reduction in the water spread in the lakes over the years, using multi-date (different years/months) satellite data.

Comparisons were made to assess the changes taking place in various years. The area of a lake, comparison of present area with that of the past and differentiation between water bodies with and without water hyacinth cover were recorded.

Satellite images (geocoded false colour composites) on a 1:50,000 scale were used to assess the area of the water hyacinth cover and that devoid of water hyacinth during summer (1989, 1994, 1998) and winter seasons (1988, 1993, 1998; see Figure 3 a–c respectively).

The months and years taken up for the study included December 1988, March 1989, November 1993, March 1994, March 1998 and November 1998. Satellite images for January 2000 and January 2001 are shown in Figure 4 and for October 1998 in Figure 5.

From the satellite data the areas with and without water hyacinth cover were identified and the extent was
worked out in hectares. The two areas then put together gave the total area.

Water quality and soil quality analyses were carried out using standard methods.

Climatological features, rainfall and temperatures of the present year were noted (1999–2001).

The original areas of the lakes as measured from the map published in 1974 were: Doddabommasandra 46.44 ha, Yelahanka 135.68 ha, Jakkur 115.8 ha, Nagavra 43.86 ha and Hebbal 77.95 ha, the measurements from satellite remote sensing images (November 1998) are 33.45 ha, 98.75 ha, 62 ha, 33.5 ha and 57.75 ha respectively.

Among these lakes the largest is the Yelahanka lake followed by Jakkur, Hebbal, Doddabommasandra and Nagavra lakes. Yelahanka lake has maximum water hyacinth cover. It was recorded that the water area in March 1998 had decreased as compared to March 1989 (ten-year span). Bangalore city showed maximum and minimum temperature in summer and winter as nearly 32.1 and 18.8°C in summer, and 26.3 and 14.8°C in winter during 1999 and 32.9 and 21°C in summer and 28.2 and 16.8°C in winter during 2000. These temperatures are ideal for growth and multiplication of water hyacinth with low humidity in summer and high humidity.
Pollution is quantified with physico-chemical and biological data of the field. Qualification of pollution levels and spread of aquatic vegetation in a water body was due to high ammoniacal nitrogen (28.6 mg/l), maximum alkalinity (617.67 mg/l), increase in BOD (334.93 mg/l) in water hyacinth regions with a decrease in the dissolved oxygen (DO; 4.38 mg/l), high COD (200.43 mg/l) and sodium (168 mg/l). Concentration of iron was high in water-hyacinth growing regions (6.10 mg/l), calcium concentration was 223.3 mg/l and total solids 3781.19 mg/l. Lakes devoid of water hyacinth had better water quality, with much lesser ranges of pollutants. This showed that high pollution range had highly robust growth of water hyacinth covering large areas, compared to less polluted lakes with chloride level at 323.85 mg/l and fluoride level at 0.3 mg/l. Water-hyacinth growing regions showed 20 to 31.25 cm depth of transparency, whereas in regions without water hyacinth it varied from 25 to 42.5 cm. These were measured using the Secchi disc.

Soil analysis of water-hyacinth growing areas showed that lime, calcium, magnesium and total acidity were 1.92, 1.16, 0.29 and 4.35% respectively, in polluted lakes infested with water hyacinth.

The Doddabommasandra lake had 2.75 ha covered by the water hyacinth during November 1989 and March 1998. During some years, water hyacinth was absent. But the area in a less moderately polluted (pollutants at low lev-
Figure 3. *a, b*, Lakes mapped from IRS satellite images.
c) water body had similar conditions while in 1989 the water area was 36.23 ha and in November 1998 it was 30.7 ha in Doddabommasandra showing diminishing area of the water spread in the lake ecosystem.


Along with the lakes mentioned above, like the Hebbal lake, it has been observed over the years that government officials and the City Corporation have spent a lot of money on manual removal of water hyacinth plants when it spread on the lake surface. The satellite images were observed during March 1989 and November 1993 (20 ha reduced to 4.75 ha water-hyacinth cover). The reason for this may be due to removal of water-hyacinth mats. Ranging to about small-large fluctuation by these means.

A control lake, the Rachenahalli lake, was also studied, which did not show any water-hyacinth growth during the period 1999–2002 in comparison to other lakes. During the years 1989 and 1993, high water-hyacinth cover was observed in Rachenahalli whereas the other years had less water-hyacinth growth. The Rachenahalli lake was studied to compare the satellite images during the recent years, which were different from those of the other lakes that harboured water-hyacinth. The lake had highest water-hyacinth spread of 13.0 ha in 1989 and nil in 1998. In 1994 and 1998, Jakkur had high water-hyacinth growth (16.25 ha in 1988), and other seasons varied with decrease in the water-hyacinth seen in the years. Yelahanka had the highest weed growth (21 ha) in 1998 compared to other seasons. In 1988, there was no water hyacinth seen in this lake (Table 1). Based on satellite image calculations, at present the maximum weed cover is seen in the Nagavara and Yelahanka lakes, with more than half the area of these lakes being under the water hyacinth cover. This could be due to the direct entry of untreated sewage water. Water-hyacinth takes up the nutrients and multiplies rapidly; hence the reduction in water-spread area, which has been occupied by water-hyacinth. The increase in water-hyacinth cover in Yelahanka and Nagavara lakes was recorded over the years. These lakes were also more polluted compared to the remaining lakes (Figures 3–5), as indicated by water-quality testing.

The agricultural and natural vegetation in the watershed of the tank (including important variables), as seen from the image of January 2001, is around 60% under built-up area and around 30% plantations/agriculture. The accuracy of interpretation from the satellite data is 95%.
The light reflectance characteristics of water hyacinth (*E. crassipes*) and the application of airborne videography with Global Positioning System (GPS) and Geographic Information System (GIS) technologies have been extensively used for distinguishing and mapping the distribution of aquatic weeds in waterways of southern Texas, USA. Field reflectance measurements made at several locations showed that water hyacinth generally...
Table 1. Water spread and area under water-hyacinth cover of lakes over the years (derived using Indian Remote Sensing Satellite Images) (in ha)

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<tr>
<td>DB Sandra</td>
<td>41.5</td>
<td>Nil</td>
<td>36.23</td>
<td>2.75</td>
<td>33.5</td>
<td>0.75</td>
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<td>Yelahanka</td>
<td>108.25</td>
<td>Nil</td>
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<td>10.5</td>
<td>107.5</td>
<td>5.75</td>
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<tr>
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<td>52</td>
<td>16.25</td>
<td>38.75</td>
<td>8.75</td>
<td>51.75</td>
<td>2.75</td>
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<tr>
<td>Rachanahalli</td>
<td>47.5</td>
<td>3.25</td>
<td>10.5</td>
<td>13.0</td>
<td>40.25</td>
<td>9.5</td>
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<tr>
<td>Nagavara</td>
<td>22.75</td>
<td>6.5</td>
<td>14.0</td>
<td>15.25</td>
<td>24.25</td>
<td>13.50</td>
</tr>
<tr>
<td>Hebbal</td>
<td>40.25</td>
<td>8.75</td>
<td>30.0</td>
<td>20.0</td>
<td>46.25</td>
<td>4.75</td>
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*W, Water; Wh, Water hyacinth.

had higher near-infrared (NIR) reflectance than associated plant species and water. Water hyacinth and hydridra could be distinguished in Colour Infrared (CIR) video imagery where they had bright orange-red and reddish-brown image responses respectively. Computer analysis of the imagery showed that water hyacinth and hydridra infestations could be quantified. An accuracy assessment performed on the classified image showed an overall accuracy of 87.7%.

Indian remote sensing satellite imageries were used to measure the area of water spread and water-hyacinth cover. These were helpful in calculating data on the area of the entire lake and weed cover with the present environmental conditions, with an accuracy of about 95%.

Studies at Space Applications Centre (SAC) covering five lakes (Dal, Wular, Kolleru, Chilka and Pulicat in different parts of India) and three reservoirs have shown mapping of turbidity levels, representing suspended sediment concentration, and distribution of aquatic vegetation, which are possible through remote sensing.

The water area of almost all lakes has reduced in recent years and water-hyacinth growth has increased. The water in the lakes has decreased due to various activities like entry of waste from several sources, untreated sewage entry and improper management of the aquatic ecosystem.

The satellite data of March 1998 in comparison with map of 1974, indicated the analysis of actual area of the lake (water hyacinth and non-water hyacinth regions) and showed Doodhambassandra lake with 34 ha, Yelahanka with 71.5 ha, Jakkur lake with 39.5 ha, Nagavara lake with 32 ha and Hebbal lake with 59.5 ha respectively. Only Rachanahalli lake with 23 ha showed no water hyacinth growth in 1998. These values show that the area under water spread has gradually decreased in the recent years because of various activities such as mismanagement of the water resources. Manual or mechanical removal of water hyacinth, during different periods as well as the time and season of the satellite image taken are both important factors in determining the condition and status of water hyacinth in the water body (as observed in Hebbal lake). Drastic reduction in the water hyacinth cover in Hebbal lake was probably due to various physical and chemical activities taking place over the decade.

ASTER images were taken during spring to check the river. In one area shown in the ASTER images in a span of just six weeks, a single blockage grew by over a mile and a half, which is about 200 feet of river per day. There is a reason why they call water hyacinth 'the world's worst weed'.

Not only are remote sensing data valuable for detecting invasions, but also for monitoring how well control techniques work. Researchers at KARS compare imagery acquired on different dates to observe changes. This not only allows detection of outbreaks, but is useful for gauging how fast the plants are spreading and for tracking how well control techniques are working. This is done by interpretation of satellite data.

Based on the present satellite images analysis (March 1998) the maximum water-hyacinth cover is seen in the Nagavara and Yelahanka lakes, with more than half the area of these lakes respectively, being under water-hyacinth cover. This is because of the entry of untreated sewage water, which has increased over the years. Water hyacinth gets nutrients and multiplies rapidly; hence the reduction in the water spread area, which is now occupied by water hyacinth.

The maximum water-hyacinth cover was seen in the Nagavara (10.7 ha), Hebbal (9.6 ha) and Yelahanka (8.1 ha) lakes (average of the different years). The above data show the polluted lake as indicated by the water quality, with more area under water-hyacinth coverage compared to lakes where pollution was comparatively less.

Water area has been reduced in the recent years and the weeds have occupied the area. The satellite imageries show that the water in the lakes has decreased.

The area under water-hyacinth cover has increased with pollution activities from various sources, especially sewage water rich in organic matter, which has led to
excess growth of water hyacinth. Water quality and climate data show that high pollution supported robust growth of water hyacinth.

The study has shown that the lakes with water hyacinth infestation can be mapped using remote sensing data more accurately than field visits. The fluctuation and changes taking place as well as seasonal variations were detected. These data showed the water hyacinth regions expanding over the years.

Work on water hyacinth parameters would be useful in future, in a wide range of areas, from weed ecology to water-resource management. Monitoring water hyacinth with good accuracy would be useful in aspects concerning the dynamics of the environment.


ACKNOWLEDGEMENTS. We thank Dr. M. A. Paul, ISRO, Bangalore, Dr. Sushil Kumar Jalali and Dr. Chandish R. Ballal, DBHC, ICR, Bangalore for their valuable inputs. We also thank the two referees for useful comments and suggestions.

Received 30 July 2002; revised accepted 25 January 2003

Do informally managed sacred groves have higher richness and regeneration of medicinal plants than state-managed reserve forests?

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Sacred groves are ‘traditionally managed’ forest patches that functionally link social life and forest management system of a region. It is believed that one of the prime utilities of sacred groves is the protection and occasional supply of medicinal plants. We assessed the regeneration among sacred groves of the central Western Ghats, India, and compared it with the ‘state-managed reserve forests’. Overall, nearly 60% of the regenerating species were medicinally important. The density of regenerating medicinal plants among sacred groves was almost twice as that of reserve forests. There were a higher number of seedlings (Class-II), saplings (Class-III) and poles (Class-IV) of medicinally important plants in sacred groves than among reserve forests. Further, we found that nearly 40% of medicinally important species were unique to sacred groves; in contrast, only 11% was unique to reserve forests. However, nearly equal proportions (29 vs 27%) of ‘non-medicinal plants’ were unique to sacred groves and to reserve forests. These results suggest that informal management systems such as sacred groves have not only conserved useful species, but people have tended to ‘discover’ medicinal values more often among plants unique to sacred groves, than those found in other landscapes. Perhaps, this typifies one preliminary step in medicinal-plant domestication.

‘SACRED groves’ are patches of forests that are informally managed as part of a local cultural tradition, without much intervention from State Forest Departments. They represent a functional link between social life and forest management system of a region. The concept of sacred groves is still followed in a few ethnic groups in the world and there are certain micro-sites in India, where such traditional forest management has sustained over the years due to support from native communities. Kodagu district in the central Western Ghats, South India is regarded as the ‘global hot spot for sacred groves’, because there are over 1200 sacred groves documented in

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