Forest area estimation and reporting: implications for conservation, management and REDD+

N. H. Ravindranath*, I. K. Murthy, Joshi Priya, Sujata Upgupta, Swapan Mehra and Srivastava Nalin

Periodic estimation, monitoring and reporting on area under forest and plantation types and afforestation rates are critical to forest and biodiversity conservation, sustainable forest management and for meeting international commitments. This article is aimed at assessing the adequacy of the current monitoring and reporting approach adopted in India in the context of new challenges of conservation and reporting to international conventions and agencies. The analysis shows that the current mode of monitoring and reporting of forest area is inadequate to meet the national and international requirements. India could be potentially over-reporting the area under forests by including many non-forest tree categories such as commercial plantations of coconut, cashew, coffee and rubber, and fruit orchards. India may also be under-reporting deforestation by reporting only gross forest area at the state and national levels. There is a need for monitoring and reporting of forest cover, deforestation and afforestation rates according to categories such as (i) natural/ primary forest, (ii) secondary/degraded forests, (iii) forest plantations, (iv) commercial plantations, (v) fruit orchards and (vi) scattered trees.

Keywords: Afforestation, deforestation, forest cover, monitoring and reporting, REDD+

FORESTS, particularly in the tropical countries are receiving increasing attention due to a number of reasons such as deforestation and its contribution to global CO_2 emissions, leading to climate change and loss of biodiversity and ecosystem services. In the global context, there is also an increasing realization on the need for periodic assessment and monitoring of the state of forests and biodiversity, flow of ecosystem services, rates of deforestation, factors driving deforestation and forest carbon stock changes. India, along with Brazil, Indonesia and South Africa, is one of the leading tropical countries periodically monitoring and reporting the state of forests as well as area under forests, using the latest remote sensing techniques[1]. The Forest Survey of India (FSI) is the designated agency to periodically monitor and report the changes in area under forests. Data on area under forests and different forest types and rates of deforestation, degradation, afforestation and reforestation are of great importance in promoting forest conservation. It also allows enforcing the forest legislations aimed at conservation and regeneration of the forests, and for addressing the needs of Biodiversity and Climate Change Convention and mechanisms such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) and CDM (Clean Development Mechanism).

The FSI and the National Remote Sensing Centre or Agency (NRSC/A) are two agencies involved in forest monitoring at the national level. Forest cover in India has been systematically monitored every two years since 1987 by FSI. Rapid advancements in the field of remote sensing over the last two decades have enabled the FSI to comprehensively produce 12 State of Forest Reports (SFRs)[2], with continuous improvement in the methodology used for forest cover assessment. The FSI has adopted a system of wall-to-wall mapping of forest cover and reports data on forest, mangrove and tree cover, and trees outside forests. More than two decades of systematic and regular forest cover mapping in India by the FSI has been accompanied by continued advancements in the field of remote sensing and interpretational techniques. Digital interpretation started from 2001 for the data period 2000, with a finer scale of 1 : 50,000 and a mappable area of one ha (ref. 2).

According to the SFRs published by FSI biennially, the area under forests in the recent years has been increasing

N. H. Ravindranath, I. K. Murthy, Joshi Priya and Sujata Upgupta are in the Centre for Sustainable Technologies, Indian Institute of Science, Bangalore 560 012, India; Swapan Mehra is in the Iora Ecological Solutions Pvt Ltd, New Delhi 110 030, India; Srivastava Nalin is in the Institute for Global Environment Strategies, 2108-11, Kamiyamaguchi, Hayama, Kanagawa 240-0115, Japan.
*For correspondence. (e-mail: ravi@ces.iisc.ernet.in)

steadily[2]. However, a study by Ravindranath et al.[1] using published data of FSI, has concluded that India is experiencing significant scale deforestation and forest degradation. Similarly, an assessment by Puyravaud et al.[3] has shown that there is loss of India's native forests. Gilbert[4] has also highlighted the controversy over the area under forests in India. Thus, there is a need for review and assessment of forest area monitoring and reporting in India. This article deals with the following: (i) Trace the evolution of forest monitoring in India. (ii) Assess the methods and approaches adopted for forest monitoring and reporting. (iii) Definition of forest, area under forests, deforestation rates. (iv) Implications of forest area monitoring and reporting, to meet the needs of forest conservation and international obligations such as REDD+.

Definition of forest and what constitutes 'forests' in India

Definition of forest is critical and is the first step in estimation of area under forests. It is particularly important to have a consistent definition across countries for comparison.

FAO

FAO[5] defines forests as 'land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 per cent, or trees able to reach these thresholds *in situ*' for reporting area under forests under Forest Resources Assessment (FRA). It does not include land area with trees that is predominantly under agricultural or urban land use.

UNFCCC

According to the Climate Change Convention[6], 'Forest is a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 meters at maturity *in situ*. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest.'

UNEP/CBD/SBSTTA

According to the Convention on Biodiversity (CBD)[7], 'Forest is a land area of more than 0.5 ha, with a tree canopy cover of more than 10%, which is not primarily under agricultural or other specific non-forest land use. In the case of young forests or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m *in situ*, and of meeting the canopy cover requirement.'

Definition of forest cover according to FSI

The FSI defines forest cover as 'all lands more than one hectare in area, with a tree canopy density of more than 10%, irrespective of ownership and legal status'. In this article, the terms 'forest area' and 'forest cover' are used synonymously. Thus forest cover, as reported by SFR in India does not make any distinction between the origin of tree crops (whether natural or man-made) or tree species and encompasses all types of land irrespective of their ownership, predominant land use and legal status, thereby including all tree species along with bamboos, fruit-bearing trees, coconut, palm trees, etc. and all areas meeting the above defined criteria, irrespective of whether it is forest, private community or institutional land[2]. Thus forest cover as reported by FSI includes a number of land-use categories which qualify based on the tree crown cover and area eligibility criteria.

Forest and tree cover in India

Forest cover

The area under forests according to periodic SFRs is given in Figure 1. During the period 1987–1997, the area under forests has marginally fluctuated, probably due to change in methods, scale and interpretation techniques. Since 1997, the total forest cover seems to have steadily increased from 63 to about 69 mha in 2011. Forest cover has also increased from 2001, when digital interpretation method was adopted along with a finer resolution scale of
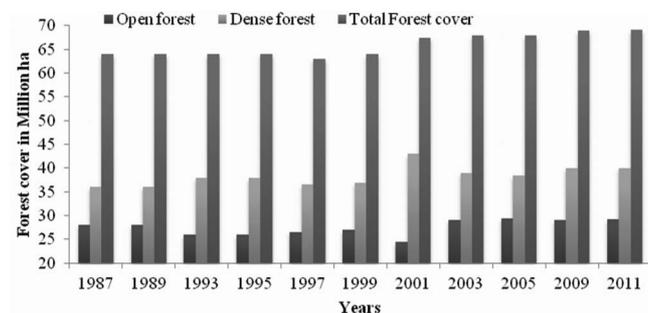
Figure 1. Area under forests according to State of Forest Reports over the period 1987 to 2011 (ref. 2). Open forest: All lands with tree cover (including mangrove cover) of canopy density between 10% and 40%. Dense forest: Includes both very dense (canopy density >70%) and moderately dense forests (canopy density between 40% and 70%).

1 : 50,000. This reported increase in forest cover could be due to any or all of the following reasons: first, forest area could be increasing with no loss of existing forest area; secondly, afforestation rates could be higher than deforestation rates, showing a continuous increase in forest cover; thirdly, area under commercial plantations, agro-forestry systems and fruit orchards may have increased, contributing to increased total area under forest cover, even when the actual primary forest cover may not have increased or indeed decreased.

Area under non-forest categories

Forest cover includes areas under all perennial tree cover, meeting the definition of forest, especially with respect to tree crown cover and area. The area under 'plantations/orchards', 'potentially' qualifying as forest is given in Table 1. Forest plantations according to FAO[5] consist of forests predominantly composed of trees established through planting and/or deliberate seeding. According to SFR[2], plantations and trees outside forests account for only 5% of total forest cover, which is about 3.46 mha. Orchards and commercial plantations which could be potentially classified as 'forest' account for about 8.79 mha (Table 1) or 12.7% of the total forest cover. Thus, even if forest plantations are considered and included as forests, the area under forests could reduce from 69.2 (21.05%) mha (ref. 2) to 60.4 mha, if dominant orchards and commercial plantations such as coconut, coffee, mango, cashewnut, etc. are excluded. Further, it can be noted from Table 2 that the area under fruit orchards and commercial plantations has increased during the period 2000–2010. Thus, it is quite likely that part of the incremental forest cover reported during this period could include increased area under orchards and commercial plantations. While there are no data on what percentage of the area under forest plantations, orchards and commercial plantations meets the definition of forest, especially the 1 ha criterion, many crops such as apple, rubber, coffee, oil palm and cashewnut are likely to be larger plantations of multiple hectares in size qualifying the forest criteria.

Is India overestimating its forest cover?

The discussion and observations from Figure 1 on forest cover as reported by SFR and the area of plantations/orchards (Tables 1 and 2) included under forests clearly indicate that the area under forests in India is being overestimated by about 12.7% (8.79 mha from Table 1 and 69.2 mha from Figure 1). The forest cover reported by FSI includes several plantation/orchard vegetation categories such as coffee, coconut, mango, cashewnut and apple. There is a need to distinguish between forest and other tree/vegetation categories. The overestimation of forest cover may have implications for forest conservation policies and programmes, and the effectiveness of these programmes, especially in the recent decades.

Is there deforestation in India?

Deforestation is defined by FAO as 'the conversion of forest to another land use or long-term reduction of the tree canopy cover below the minimum 10% threshold'[5]. Further, UNFCCC defines deforestation as 'the direct human-induced conversion of forested land to non-forested land'[6]. Here in the absence of data on forest conversion to non-forest uses, loss of canopy density of forests to below 10%, during the monitoring period, is considered as loss of forest area and potentially deforestation. Observation of data on the total forest cover as reported by FSI (Figure 1) in the SFRs biennially shows that the

Table 1. Area under commercial plantations and orchards[#]

Commercial plantations and orchards*	Area ('000 ha)	Reference
Tea	579.4	13
Coffee	409.6	14
Arecanut	463.9	15
Coconut	1894.6	16
Rubber	734.8	17
Citrus	846.5	18
Mango	2297.0	18
Saffron	2.9	19
Oil palm	164.0	20
Almond and walnut	137.0	18
Apple	282.9	21
Cashewnut	978.8	15
Total	8791.4	

[#]This table assumes that the area under plantations/orchards meets the definition of forest, especially the 1 ha unit adopted by the Forest Survey of India. There are no data to state what proportion of the total area under this category constitutes greater than 1 ha units.
*Orchards and commercial plantations exclude area under *Acacia catechu*, *Cinchona*, *Cryptomeria*, *Poplars*, etc.

Table 2. Growth in the area under commercial plantations and orchards (in '000 ha)

	1991–92	2000–01	2010–11	Change in area (2000–2010)	Change (%)
Coffee	270.8	346.7	404.6	57.9	14.3
Coconut	1513.9	1823.9	1895.9	72.0	3.8
Arecanut	217.0	285.5	400.1	114.6	28.6
Mango	1077.6	1522.6	2297.0	774.4	33.7
Apple	194.5	239.8	289.1	49.3	17.1
Oil palm	NA	NA	164.0	–	–
Cashewnut	532.0	720.0	945.0	225.0	23.8
Rubber	488.5	562.6	734.8	172.2	30.6

forest cover has been increasing since 1997, in particular from 2001 and there is no deforestation. But, according to an assessment made by Ravindranath et al.[1], using the data from SFRs, India is currently experiencing deforestation and forest degradation. Forest cover loss or deforestation in India for the recent periods was estimated by Ravindranath et al.[1] at the district level by considering (i) area of forest remaining forest between two periods, (ii) afforested or planted area (reaching canopy cover threshold of 10%) and (iii) loss of forest area. The study assumed that a district recording a net decrease in forest cover between two periods of assessment is experiencing deforestation. District-level analysis of deforestation, including area under tree plantations for the latest assessment period 2007–09 is estimated to be 199,700 ha (0.06%), at an annual deforestation rate of 99,850 ha. If forests are lost in a district, and at the same time, if afforestation has occurred at a rate faster than deforestation, it will be recorded as net gain in forest cover, even though deforestation has occurred. Similarly, no deforestation will be reported if primary forests are converted to plantations or orchards, leading to net gain or no net loss of forest cover. Further, area under fruit orchards and commercial plantations is increasing in India (Table 2), potentially contributing to the reported increase in forest area.

Need for reporting of area under forest and non-forest plantation categories

Estimation, monitoring and reporting of area under forests, deforestation and afforestation are required at local, national and international levels for multiple purposes.

UNFCCC reporting

UNFCCC requires all countries to report a definition of forests under the Kyoto Protocol. Currently, India has provided the following definition of forest to UNFCCC: 'Lands with tree crown cover value of 15% or equivalent stocking level and a land area value of 0.05 hectare and a tree height value of 5 metres'.

GHG emissions reporting for National Communications to the UNFCCC

According to the guidelines for the preparation of National Communication by non-Annex I parties to the UNFCCC, estimation and reporting of carbon stock changes and non-CO_2 emissions and removals as part of the GHG inventory for the National Communications to the UNFCCC require reporting of GHG emissions according to IPCC land-use categories – Forest Land, Cropland, Grassland, Wetland, Settlements and Other Lands[8]. According to this stratification of land-use cate-

gories by IPCC, agro-forestry systems and fruit orchards are generally reported under 'Cropland' category and not under 'Forest Land'. A national definition of forest enables GHG inventory reporting according to IPCC land-use categories for the National Communications to the UNFCCC.

Reporting to FAO

FAO collects and analyses data on forest area reported by countries in a standard format at intervals of 5–10 years as part of the Global FRA. Countries have to provide data on forest areas and forest cover loss amongst other variables, using the FAO definition for forest[5]. However, a nationally harmonized definition of forest based on the FAO definition amongst others, will make the process of collecting and analysing data on the extent of forest and forest cover loss much easier to implement.

Clean development mechanism

India is hosting afforestation or reforestation projects under the clean development mechanism (CDM), since it selected and reported the single minimum values of tree crown cover, land area and tree height[9]. According to the definition of forest submitted by India to UNFCCC, the tree crown cover threshold is defined at 15%. However, FSI monitoring and reporting uses a threshold of 10%. Thus, any CDM project would require reclassification of the forest area using the 15% tree crown cover threshold, involving significant efforts. Thus, it is desirable to have a consistent definition of forest for national and UNFCCC reporting.

Reducing emissions from deforestation and forest degradation

'Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries' (REDD+), primarily a mechanism to address the emissions from deforestation and degradation of forests in developing countries, has been under negotiation in the UNFCCC since 2005. Negotiations on REDD+ have centred on both policy aspects as well as methodological issues such as measuring, reporting and verification (MRV) of forest related emissions and removals and those resulting from the implementation of REDD+ activities. Methodological guidelines for MRV for the REDD+ mechanism have recently been agreed by parties to the UNFCCC in COP19 at Warsaw[10]. These provide that the data and information used by parties in the estimation of anthropogenic forest-related emissions and removals, forest carbon stocks and areas,

and their changes for REDD+ activities should be transparent, consistent over time and with the established forest reference emission levels and/or forest reference levels. It is important to highlight that the modalities for REDD+ forest reference emission levels and forest reference levels[11] provide that forest reference emission levels and forest reference levels shall be established maintaining consistency with the national GHG inventories of the countries. As explained earlier, national GHG inventories of the countries are compiled according to the IPCC guidelines, further estimate and report emissions and removals according to the six IPCC land-use categories.

It is therefore clear that methodologies for REDD+ projects used by countries will require a definition of forest and presentation of a land-use change matrix, according to the six IPCC landuse categories. This could potentially involve the concept of predominant land use to determine the land-use category classification of lands with perennial tree cover. For example, fruit orchards and agro-forestry, even if they meet the definition of forest according to crown cover, could be classified as 'Crop-Land' and not 'Forest Land'. While under the Kyoto Protocol, deforestation has been defined as 'the direct human induced conversion of forest land to non-forest land', its definition under REDD+ has not been clearly provided. However, since the REDD+ methodologies, including definitions have to maintain consistency with national GHG inventories, countries can use their national definitions of land-use categories for REDD+, as they normally do for their national GHG inventories, and consequently also define deforestation using a country-specific definition. In this context, India as indeed all developing countries, should explore the possibility of having a definition of forest that is consistent across various reporting frameworks and applying it consistently across time for the development of land-use change matrix according to the six IPCC land-use categories for monitoring and reporting of deforestation rates, construction of forest reference level and estimation of carbon stock changes and non-CO_2 emissions from forests.

National forest conservation policies and programmes

India has effective forest conservation legislations such as the Forest Conservation Act of 1980 and National Forest Policy, 1988. The current definition of forest cover adopted by FSI includes all perennial tree cover. This may not be adequate for national policy makers, State Forest Departments and conservationists in assessing the actual state of forests, deforestation rates (in particular the loss of primary forests), status of biodiversity and conversion of primary forest to commercial plantations or fruit orchards or annual crops. Currently, there could be complacency in India, assuming that area under forest is stable and only increasing, leading to an assumption that there is no deforestation or forest degradation.

Common forest definition and stratification for national and international reporting

To improve the quality of data, reduce the cost and increase utility, it is desirable to have a common definition of forest and stratification criteria for meeting national and international reporting requirements.

Approach to reporting forest cover in India

Keeping in mind the multiple stakeholders who need forest cover data and information, the following stratification scheme is suggested.

(i) Natural or primary forests: Information on area and spatial distribution would provide an idea of the status and extent of biodiversity-rich primary forests. If the loss of primary forest is masked under the total area change figures, the policy-makers as well as conservationists would never know the true extent of loss in order to be able to take appropriate measures to conserve them. Currently, any loss of primary forest is not visible in the national reporting in India. Spatial information on the decline and loss of primary forest is critical to prioritizing interventions to halt deforestation and promote conservation measures.

(ii) Secondary/degraded forests: Information on the extent and spatial distribution of secondary forests and the rates of change over the years from primary to secondary forests would enable initiating measures to regenerate the degraded forests. Identification of secondary forests would assist in developing programmes to regenerate the degraded forests.

(iii) Forest plantations: India has been implementing one of the largest afforestation programmes in the world[12] and annually between 1 and 1.5 mha has been afforested since 1980. It is not clear how much of the total area reported as forest under SFR is constituted by forest plantations. It is also not known if natural or secondary forests are being converted to forest plantations. Large investment is going into afforestation programmes in India and it is not clear how much of the planted area has survived and matured into forests. Thus, it is important to generate separately spatial distribution of area under forest plantations at decentralized or local levels.

(iv) Commercial plantations: It may not be environmentally sound to include plantations raised for commercial purposes, which are largely monocultures and intensively managed (with weed removal, fertilizer, herbicide and

pesticide application), as forests. It will be important to know if and to what extent commercial plantations such as coffee or rubber are grown by converting secondary or even primary forests to enable enforcement of forest conservation regulations.

(v) Fruit orchards: These are grown for commercial purposes and are largely characterized by monocultures, often clonally propagated and subjected to intensive management (weeding, fertilizer and pesticide application). Thus, it is important to report area under fruit orchards along with spatial map of the distribution of fruit orchards, especially if secondary or even primary forests are converted to orchards.

(vi) Trees outside forests: Trees are grown in croplands and homesteads, and along avenues, railway line and canals, which do not qualify as any of the above categories. These need to be monitored and reported to enable estimation of carbon stocks and agro-biodiversity.

Conclusion

An analysis of the monitoring and reporting approach followed in India showed the inadequacy of current procedures for meeting the needs of conservation, research and UNFCCC reporting. India could be potentially over-reporting the forest cover by including many plantation categories (such as coconut, arecanut, cashew, coffee and rubber) and fruit orchards (such as mango, orange and apple). Even the inclusion of plantations of *Eucalyptus*, *Casuarina*, *Poplar*, etc. under forest cover is questionable from a conservation perspective. India also could be potentially under-reporting deforestation by reporting only the gross forest area and changes at the national and state levels, which may mask any forest loss, if the rate of afforestation is higher than deforestation rates. Thus, there is need for a new approach to monitoring and reporting of forest area in India, to meet the challenges of forest conservation, research and reporting to UN agencies such as FAO, UNFCCC (National Communications, CDM and REDD+) and CBD. Forest cover monitoring and reporting could adopt the following stratification scheme: (i) natural/primary/native forest, (ii) secondary/degraded forests, (iii) forest plantations, (iv) commercial plantations, (v) fruit orchards and (vi) trees outside forests. Many other developing countries such as Indonesia and South Africa[5] are monitoring and reporting forest area according to forest type (natural and plantations), and the purpose of management (conservation, protection and production). Digital and spatially explicit maps of forest and plantation cover as well as data and information should be accessible to users, to enable increased utility and transparency.

1. Ravindranath, N. H., Srivastava, N., Murthy, I. K., Malaviya, S., Munsi, M. and Sharma, N., Deforestation and forest degradation in India – implications for REDD+. *Curr. Sci.*, 2012, **102**, 1117–1125.
2. State of Forest Reports, 1987 to 2011. Forest Survey of India, Dehradun.
3. Puyravaud, J. P., Davidar, P. and Laurance, W. F., Cryptic loss of India's forests. *Conserv. Lett.*, 2010, **3**, 390–394.
4. Gilbert, N., India's forest area in doubt. *Nature*, 2012, **489**, 14–15.
5. FAO, Global forest resources assessment. FAO Forestry Paper 163, Food and Agriculture Organization, Rome, 2010.
6. UNFCCC, Seventh Conference of Parties: The Marrakech Accords (UNFCCC Secretariat, Bonn), 2001; http://www.unfccc.int
7. UNEP, UNEP/CBD/SBSTTA/7/INF/12, Subsidiary Body on Scientific, Technical and Technological Advice, Convention on Biological Diversity, 5 November 2001.
8. UNFCCC, Decision 17/CP.8: Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention. FCCC/CP/2002/7/Add.2, United Nations Framework Convention on Climate Change, Bonn, Germany, 2002.
9. UNFCCC, Decision 16/CMP.1: land use, land-use change and forestry, FCCC/KP/CMP/2005/8/Add.3, 2006.
10. Decision CP.19 on modalities for measuring, reporting and verifying reached at COP19 in Warsaw, December 2013.
11. UNFCCC, Report of the conference of the parties on its seventeenth session, held in Durban from 28 November to 11 December 2011, addendum part two: action taken by the conference of the parties at its seventeenth session. Decisions adopted by the conference of the parties. Decision 12/CP. 17 Guidance on systems for providing information on how safeguards are addressed and respected and modalities relating to forest reference emission levels and forest reference levels as referred to in decision 1/CP.16 (FCCC/CP/2011/9/Add.2), 2012.
12. Ravindranath, N. H., Chaturvedi, R. K. and Murthy, I. K., Forest conservation, afforestation and reforestation in India: implications for forest carbon stocks. *Curr. Sci.*, 2008, **95**, 216–222.
13. Tea database, 2011; http://www.teaboard.gov.in/pdf/stat/Area.pdf
14. Database on coffee, Market Intelligence and Statistical Unit Coffee Board, 2013; http://www.indiacoffee.org/userfiles/DATABASE-Jan13_I[1].pdf
15. Indiastat, 2011–12; http://www.indiastat.com
16. Coconut Board, 2008–09; http://coconutboard.nic.in/stat.htm
17. Rubber Statistical News, National Rubber Board, 2011–12; http://rubberboard.org.in/monstatsdisplay.asp
18. National Horticulture Database, 2011; http://nhb.gov.in/area-pro/database-2011.pdf
19. Indiastat, 2006–07; http://www.indiastat.com
20. *DOPR Vision 2030*, Directorate of Oil Palm Research, Indian Council of Agricultural Research, West Godavari Dist, Andhra Pradesh, ISBN: 81-87561-26-2, http://dopr.gov.in/Reports/DOPR_Vision_2030.pdf
21. Maps of India, Apple Production 2011; http://www.mapsofindia.com/indiaagriculture/fruits-map/apple-producing-states.html