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Joint Indo-German Research Workshop

Will Competition for Land and Water Hinder Energy Development in India ?

NATIONAL INSTITUTE OF ADVANCED STUDIES

Center for Environmental Systems Research

Joint Indo-German Research Workshop

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National Institute of Advanced Studies
Indian Institute of Science Campus, Bangalore

7-8 March 2006

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Joint Workshop Report of

National Institute of Advanced Studies
Indian Institute of Science Campus
Bangalore, India 560 012

Center for Environmental Systems Research
University of Kassel, Kassel, Germany 34109

Joint Indo-German Research Workshop:
Will Competition for Land and Water Hinder Energy Development in India? – Recommendations for Research

National Institute of Advanced Studies
Indian Institute of Science Campus, Bangalore
7-8 March 2006

Workshop Report

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Summary

The rapid growth of India's economy and (material) well-being of its citizens requires many inputs including enormous amounts of energy. As an example, between 2005 and 2025 national electricity production may increase by a factor of 2.5 or more. While it seems certain that energy use and production will rapidly grow, it is not clear which future mix of fuels will deliver this energy. The success of different fuels will depend on the answer to many questions, including

Will lack of suitable land and adequate water supply hinder the exploitation of certain energy carriers?

To address this crucial question, workshop participants recommend two major actions:

1. *Conduct a national integrated assessment of liquid biofuels development in India.* Considering the central role that bioenergy is expected to play in India's energy future, it is recommended to carry out a national integrated assessment of the use of biomass to produce liquid fuels, especially ethanol and bio-diesel for use in the transportation sector and for stationary small-scale electricity production. The scale of the assessment should be both national and regional and should address the following issues: land use, food production, water availability, net energy balance of biofuels, biodiversity,

carbon sequestration, social, economic and cultural aspects, and impacts of external driving forces (e.g., international trade).

2. *Close the large knowledge gap about impacts of future large scale electricity facilities on land and water resources in India.* As compared to air pollution impacts, there is a gap in understanding the impacts of large-scale electricity production on land and water resources in India. (Here "largescale electricity production" means facilities > 500 MW). Given the strong competition for land and water in India, this knowledge gap urgently needs to be closed. The following questions in particular must be addressed – What are the land and water requirements for different fuel cycles? Where in India are water resources sufficient or insufficient for the water needs of large power generation facilities? What are the social, cultural, and economic impacts associated with land and water requirements for large electrical facilities? What are criteria for siting large electrical facilities that would help to minimize their undesirable impacts?

Acknowledgments

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1 Introduction

Since energy development is a key ingredient of material well-being and economic development, societies give high priority to planning for secure energy supplies. But the feasibility and desirability of future energy supplies depend on many uncertain variables such as the future price of different energy carriers, their local and regional availability, their impacts on settlements and society, their effect on environmental quality, and the availability of land and water for energy production. The better we can estimate these future variables, the more secure will be our future energy supplies.

Although energy future studies have been carried out for decades, new results from the scientific community now enable much more detailed and informative analyses of the feasibility of future energy development over large geographic areas. Most importantly, these tools make it possible to make a connection between global changes (large-scale changes in climate, population, land cover) and future energy production.

A Joint Indo-German research workshop, with funding from the German Research Ministry (BMBF), was held at the National Institute of Advanced Studies on March 7-8 2006 to identify critical research questions concerning the availability of land and water in promoting future energy development in India and to exchange information about the latest modeling and other tools available for studying these questions. Twenty-three participants from India and Germany participated in the Workshop. (Please see Section 4 for contact details of the participants.)

The Workshop was designed to encourage discussions of the latest knowledge about energy development in India and its relation to land and water resources. Another topic of discussion was the availability of tools for detailed assessments of the feasibility of different energy pathways in India such as scenario analysis, continental-scale crop modeling, and continental scale modeling of water resources. Particular emphasis was placed on how these tools can be used to assess the extent to which the given availability of water and/or land in India supports the development of different energy carriers.

Please see Section 5 for a detailed Program of the Workshop. Abstracts of presentations can be found in Section 3 of this report.

2 Workshop Outputs

The main output of the Workshop was the identification of two major research challenges that need to be addressed.

1. Integrated Assessment of Liquid Biofuels Development in India

2. The Impact of Large-scale Electricity Production on Land and Water in India

2.1 Integrated Assessment of Liquid Biofuels Development in India

Recommendation: Conduct a national integrated assessment of liquid biofuels development in India

Considering the central role that biomass is expected to play in India's energy future, the participants unanimously recommended carrying out an integrated assessment of the use of biomass to produces liquid fuels, especially ethanol and bio-diesel for use in transportation sector and for stationary small-scale electricity production. The time horizon for the assessment should be about 20-30 years. The integrated assessment should be driven by various feasible scenarios of future biofuel use and production in India based on:

- Economic and technical considerations,
- Expected fuel requirements for transportation,
- Future prices and other factors having to do with alternative fuels, and
- Different mixes of biofuel crops.

The participants deliberated on both the major components of this assessment and the specific questions that the assessment should address under each of these components. The major components were land use, food production, water, energy balance, biodiversity and soil conservation, carbon sequestration, social, economic and cultural aspects, and the impact of external drivers. Questions under each of these components are summarized below.

2.1.1 Land Use

1. Are degraded (and marginal) lands sufficient for biofuel development?
2. Will changing crop yields make more or less land available for biofuel development?
3. Will biofuel development lead to land use conflicts, e. g., with settlement areas, nature reserves, and food production?
4. Is multi-cropping feasible for biofuel plantations?

2.1.2 Food Production

1. Will biofuel development affect agricultural cropping patterns, and yields and production?
2. Will biofuel development divert agriculture lands from critical food production?
3. Will changing (international?) food trade make more or less land available for biofuels?

2.1.3 Water Availability

1. Will water be available when and where it is needed for biofuel development?
2. Conversely, will biofuel development exacerbate existing water stress?

2.1.4 Energy Balance (energy output: input ratio)

1. What will be the energy output: input ratio for different species of biofuel crops when their entire fuel cycle is taken into account?

2.1.5 Biodiversity & Soil Conservation

1. What impact will biofuel development have on soil fertility (enhancement or depletion) over large regions?
2. Will biofuel development affect current biodiversity and its ecological functions?
3. How do the ecosystem services provided by biofuels compare to the ecosystem services they would replace?

2.1.6 Carbon Sequestration

1. How much will carbon dioxide emissions be reduced by displacing fossil fuels with biofuels (taking into account life cycle emissions of biofuels and the fuels they would replace)?
2. How much carbon will be taken up by biofuel cropland as compared to previous uses of the land?

2.1.7 Social, Economic & Cultural Aspects

1. How will biofuel development affect livelihoods, employment, and incomes of different social groups (urban and rural)?
2. Will biofuel development increase the equitable distribution of resources in the country?
3. What economic and institutional incentives are required for stimulating and sustaining biofuel development?

2.1.8 Impact of External Drivers

1. What impact will future international trade relationships (e.g. WTO policy on biofuel trade) have on biofuel development?
2. What will be the impact of subsidies of biofuels in foreign countries on India's biofuels program?
3. How will climate change affect biofuel crop potential, average productivity, and reliability of yield?

2.2 Impact of Large Scale Electricity Production on Land and Water in India

Recommendation: Close the gap in knowledge about impacts of future large scale electricity production on land and water resources in India

As compared to air pollution impacts, there is a gap in understanding the impacts of large electricity production on land and water resources in India. Given the strong competition for land and water resources in India, this knowledge gap urgently needs to be addressed. It is judicious, therefore, to take a country-wide perspective in siting/allocating future large power generation facilities where water and land are most available so as to minimize both competition with other users, and the negative impacts of these facilities. The participants defined "large-scale" to be plants with at least 500 MW capacity.

In order to close the gap in understanding the impacts of large scale electricity production on land and water resources, the following topics urgently need to be addressed:

1. The land and water requirements for different fuel cycles should be assessed using full life cycle analyses;
2. An integrated analysis of the adequacy of country-wide water resources relative to water requirements of large power generation facilities should be undertaken. This analysis should take into account changing power plant cooling technologies, changing nationwide competitive water uses and withdrawals, and different scenarios of future electricity use.
3. The social, cultural and economic impacts associated with the land and water requirements of large power generation facilities should be assessed, including the impacts of resettlement and rehabilitation programs on project-affected families.

4. Site selection criteria should be developed so as to avoid large power generation facilities from being located at (culturally, economically, socially) sensitive sites.
5. The planned upscaling of nuclear energy capacity requires that special attention be given to the following issues, *inter alia:*
   - Assessment of land requirements for reprocessing and disposing of spent nuclear fuel and waste management;
   - Development of selection criteria for siting nuclear waste disposal facilities that comprehensively take into account impacts on land and water resources.

3 Abstracts of Presentations

3.1 Introduction to Workshop: The Impacts of Future Energy Systems

Dilip Ahuja

Globally, there are two major problems with the energy system: finding cheaper and cleaner substitutes for coal for electricity production and for oil in transport. In developing countries, providing modern energy for cooking and lighting is also a major problem. No energy form is without impacts. Mostly, impacts depend on the scale. Environmental impacts occur with scaling up even with relatively benign energy sources. When impacts of energy developments on land and water are studied, it is crucial to study the degree of irreversibility besides the amounts involved. Modern bioenergy has a large potential to meet energy requirements but also raises concerns about potential land and water conflicts. If only marginal lands were used for biofuel crops, food production might not be affected. But if a fifth of liquid fuels were expected to come from biomass, conflicts could not be ruled out. Although a program might be designed for growing non-edible oil seeds on marginal lands, if and when the economics changed, other farmers might shift to oil crops. Dual-use crops would increase systemic resilience. Analysts ought not to take sides between energy technologies, at least not prior to completing comprehensive analyses. Since we cannot estimate reliably all the costs and all the benefits, nor internalize them perfectly in the price of energy, it is better that we take a portfolio approach that simultaneously promotes many promising options.

3.2 Inaugural Address: Outlook for Energy Development in India

S. L. Rao. First Chairman of the Central Electricity Regulatory Commission and former Director General of the National Council of Applied Economic Research, New Delhi.

India needs over 100,000 additional MW of power by 2012 and a non-binding government policy is that 10% should come from renewables. Most future hydro projects are likely to be run-of-the-river projects and most of the thermal power stations may be sited along coastlines, with some fueled by imported coal. A key issue is the amount of land actually required for power projects since even relatively benign forms, such as wind power, displace farmers. If we wish to promote renewable energy such as bioenergy, wind and solar energy, it will be important to use price signals to influence behavioral shifts, for example, to encourage farmers to begin growing specific bioenergy crops.

3.3 Long-term Prospects for Developing and Using Liquid Biofuels in India.

Udupi Shrinivasa

Several different types of oil-bearing seeds in India (e.g., jatropha, mahua and castor) effectively store solar energy and can be used as a source of bio-diesel for vehicles and stationary power applications. Bangalore already has 80 buses running with 10 percent of their petro-diesel substituted by filtered bio-diesel. Modern bioenergy production is an attractive alternative for rural India. With careful planning, a typical village might be able to produce and refine enough oil seeds to cover its own power requirements and produce 40 surplus tons of oil per year for sale. Bioenergy would not only be a valuable energy source for villages, but could also provide employment and income to the many underemployed workers in India's 100 million rural households. But strategies and economics of exploiting oil-bearing seeds (types of seed crops, amounts of fertilizer, requirements for irrigation) must be specifically tuned to the type of land available in India, whether it be on existing cropland, wastelands or marginal lands.

3.4 Assessing the Potential Impacts of Large-Scale Biofuel Production

J. Gururaja

If biofuels are to become a significant player in the fuel/energy mix at national and global levels, the use of land and water on a commensurate scale is inevitable. It becomes necessary to critically examine the technical, economic, social and environmental dimensions of large scale biofuel development under different scenarios that project significant biofuel impacts in areas of transportation, greenhouse gas mitigation, energy security, and employment generation, particularly in the rural sector.

There is considerable fragmentation of information on factors that influence the nature and levels of impact concerning large scale biofuel development. Some studies have concluded that on an aggregate global level, biomass potential is capable of contributing to energy use in excess of 25% especially in the transportation sector without serious constraints on land. Further studies on land and water issues are needed at specific geographic locations in order to understand the constraints that these may impose on biofuel development, and options for addressing them.

We need to develop new methodologies for characterizing the pros and cons of biofuel options so as to help in making more informed choices. While issues such as land availability and energy input-output ratios have been discussed in various forums, a holistic view of all relevant factors in the framework of sustainable development is what is called for in order to guide specific policies in this regard. In other words, we need an integrated assessment of various factors involved. Such an integrated assessment could take a scenario approach and show for a specific geographic area, how biofuel development would interact with land uses, food production, biodiversity, soil conservation and carbon sequestration. It is suggested that social parameters should also be considered in terms of employment/income generation and poverty alleviation.

3.5 Land for food or fuel?

N.H. Ravindranath

India has many bioenergy options to meet its growing energy demand, but most of these options require vast areas of cropland for growing bioenergy crops. Therefore, a key issue is, how much land will be available for bioenergy versus food crops? Two factors are of particular importance when considering this question. First, the area under cultivation in India has stabilized in recent years because the growth in crop yield has kept up with the growth in population and income. Therefore, there seems to be no need in the immediate future to add large new areas for growing food. Second, it may be possible to allocate some existing food-growing areas to bioenergy crop production by further boosting the productivity of food crops. Indeed, crop productivity in India is still rather low compared to other Asian countries. For example, the average rice yield in India is around 1.8 t/ha as compared to 5.7 t/ha in China and 8.2

t/ha in South Korea. While it may not be feasible in the coming years to increase yields by a factor of 3 or 4, a much more modest and feasible increase could free up perhaps one-third to one-half of India's current croplands for production of bioenergy crops. Another potential location for bioenergy crops could be degraded lands or "wastelands" which are unsuitable for food production. In India roughly 130 million ha fall into this category. Of course, degraded lands would have to be rehabilitated in order to produce bioenergy crops, but the costs of this reclamation may be reasonable, while the benefits would include reduction of soil erosion, protection of sedimentation in watersheds, and increased groundwater recharge.

3.6 Modeling the potential production of biofuel crops in India: An example for sugarcane production

Joerg A. Priess and Maik Heistermann

One of the most challenging political and scientific tasks of the coming decades is to improve the livelihood of 70% of the population of India living in villages without adequate energy and water supply. Renewable energy will play an increasingly important role, since the policy target is to produce 10% of new power capacity (about 10,000 MW) with renewable energy carriers. Woody and leafy biomass are among the most important renewable energy sources for producing energy via cogeneration, gasification or as liquid fuel. In this paper we focus on the potential of the 85 Mha of shrub lands and savannas for the production of energy-crops such as sugarcane. We used the agro-ecosystem model DAYCENT to simulate the production of sugarcane at three levels of land use intensity (50 kg/ha and 100 kg/ha N fertilizer and 100 kg/ha N fertilizer plus irrigation). Dry matter production summed up to 640 to 1150 Mt per year, which is 2.8 to 5.5 times the biomass produced by current natural vegetation cover. Depending on the conversion technology used, the total energy content of 11,300 - 20,400 PJ could translate into 900 – 1600 TWh of electrical energy using a steam engine, or 240 – 430 TWh in a biogas engine plus the benefits of the N-rich organic material remaining after gasification. On the other hand, it is likely that bioenergy crops will have to compete with livestock production and food cropping for the same available shrub lands and savannas. We conclude that shrub lands and savannas in India provide large potential for bioenergy production, and that factors both within and outside the energy sector will influence the future use of these 85 Mha of land.

3.7 Simulating the impact of biofuel development on country-wide land use changes in India

Ruediger Schaldach and Joseph Alcamo

India's emerging economy generates a growing demand for energy. Facing the declining global resources of fossil fuels, the Indian government and energy industry are considering the long-term expansion of biofuel production in order to increase energy security. In a pilot scenario study, the LandShift model is applied to assess the impact of biofuel production on land use changes in India up to the year 2050. The baseline for these estimates is a simulation using socio-economic driving forces from the "Order from Strength" scenario of the Millennium Ecosystem Assessment. As a sensitivity analysis of the consequences of expanded biofuel production on land resources, it is assumed that 150 PJ of liquid fuels are produced from maize grown on Indian land in 2050. (Maize is used as a surrogate crop for other bioenergy crops.) Under this biofuel scenario, agricultural land expands by 7.2% (as compared to 5.1% under the baseline run) with one consequence being a 11.7% decrease in forest land (as compared to 4.9% under the baseline run). These simulations illustrate the utility of using LandShift to investigate large-scale, long-term land use change issues. In the simulations shown, a comprehensive linkage is made between driving forces (such as population change) and policies (such as biofuel usage) that could affect land use change in India over the coming decades. Moreover, the simulations illuminate the indirect consequences of changing demand for land on the further depletion of natural forests in India.

3.8 Will India's Electricity Production be Limited by Future Water Scarcity?

Joseph Alcamo, Martina Floerke, Tim Aus der Beek

One of the cornerstones of India's rapid economic growth is energy use. Larger and larger amounts of fuels are needed for powering vast numbers of new vehicles and for generating electricity for homes and industry. Under continuing economic and population growth, total Indian electricity production may increase by factor of 2.5 or more between 2005 and 2025 (as estimated by the Millennium Ecosystem Assessment). Although India has a diverse mix of power facilities, most new electrical generation capacity is expected to be in the form of thermal power plants which require not only fuel but also large volumes of water for cooling turbines and producing steam. Summed together, India's electricity and manufacturing sectors now account for about 6% of total national water withdrawals and are strong competitors with municipalities and agriculture for increasingly scarce water supplies. We estimate that by 2025 the river basin area where power plant withdrawals are very large and water particularly scarce could increase by approximately 50 to 100%. Here, water shortages may threaten the reliability of electrical generation. A conclusion of this analysis is that careful planning is needed to site new facilities in river basins where water supplies are reliable over the long run. In addition, new thermal power plants could be equipped with water-saving, closed-cycle cooling, and greater emphasis could be given to solar, wind and other electrical generation technologies having minimal water requirements.

3.9 The Integration of Renewable Energy and Energy Efficiency into Energy Scenarios

Indu R. Pillai, Rangan Banerjee

Most energy models focus on global/national aggregation and do not incorporate traditional fuels. Renewables & energy efficiency are not adequately detailed in energy scenarios. In this paper an approach to incorporate renewables and energy efficiency in energy scenarios is presented. An end use based framework for estimation of potential of a renewable energy-based technology linking the micro-level (single end use) and macro-level (aggregate market effects) is presented. This framework is illustrated for solar water heating systems and biomass gasifiers. A potential feasible area of 1700 m^2 solar collector area is estimated for solar water heating systems in a 2 sq. km case study area of Pune, India having a population of 10,000. The potential energy savings from this collector area is estimated to be 1.10 million kWh. The end use sectors considered are residential areas, hospitals, nursing homes and hotels. The approach presented addresses the role of renewables and energy efficiency in energy scenarios; proper linkage between different levels of energy use, and effects of different policies and markets on the feasibility of renewable energy.

3.10 Social Impacts of Hydroelectric Reservoirs

Shantha Mohan

Advancement of technology and the tremendous increase in demand for water and power has led to the construction of large dams for irrigation, hydroelectric power generation, flood control, and other purposes. Up to now construction of dams has been based mostly on technical and financial viability rather than on concerns for the people and ecosystems flooded by their construction. This paper traces the historical evolution of dam building and provides statistics on the status of dams in India. It reviews the criteria, guidelines and standards for dam construction proposed by the World Commission on Dams, the various policies of the Indian government, as well as the values stressed in the Human Development and Policy Framework for water and energy resources. These values include equity, efficiency, participatory decision-making, sustainability and accountability. The Framework argues for a holistic rights-based approach that is sensitive to the needs of people affected or displaced, particularly the vulnerable social groups such as the very poor, tribals, women and children, who bear high social costs. The Framework claims further that is the responsibility of the state to address the negative impacts of dam construction by allocating adequate funds, granting well-defined compensation packages, and providing infrastructure and facilities to the landless. Finally, the Framework suggests strategies for ensuring stakeholder participation in addressing the social impacts of the construction of dams and reservoirs.

3.11 Modeling methods for assessing local/regional impacts of energy development on water and land resources

Ralf Seppelt

Modeling and simulation are powerful and flexible tools to study, analyze and investigate environmental processes as well as to develop possible management strategies for environmental problems of the upcoming centuries. Both, increased understanding of environmental systems, as well as management strategies and scenario development are well known methodologies supported by environmental modeling. The presentation focuses on the core questions of the identification of regional impacts due to human disturbances especially land use change. It requires a theoretical concept that is able to cope with the following core questions: (i) How to specify/assess and quantify impacts, (ii) how to cope with *dynamics* of the system and (iii) how to derive *strategies* for managing the system. The concept of *ecosystem services* used in the Millennium Ecosystem Assessment is discussed. It is shown that an analysis of the dynamic development of certain ecosystem services in a specific region necessitates a fully integrated view that allows a quantified specification of the functional aspect of ecosystem services including an assessment of the resulting trade-offs. Three case studies are presented that depict the application of the concept within the framework of optimization techniques to identify optimum land use patterns of biodiversity maintenance, nutrient retention in a landscape and restructuring of urban systems.

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5 Workshop Programme

Tuesday, March 7 (Day 1)

09.00 – 09.30	Registration
09.30 -10.30	**Inaugural Session**
	Welcome Address
09.30 - 09.40	*Prof. B. V. Sreekantan, Dean, School of Humanities, NIAS*
	Genesis and Objectives of the Workshop
09.40 –09.50	*Prof. Joseph Alcamo*
	Introductory Remarks
09.50 -10.00	*Prof. Dilip Ahuja*
	Inaugural Address: Long-term Prospects for Energy Development in India
10.00-10.25	*Dr. S. L. Rao*
	Vote of Thanks
10.25-10.30	*Prof. Shantha Mohan*
10.30 -11.00	High Tea and Coffee Break
11.00 –13.00	**Session:**
	Biofuel Development and its Consequences on Land and Water
	Chair: Prof. Dilip Ahuja
11.00-11.20	Long-term Prospects for developing and using liquid biofuels in India. *Prof. Udupi Srinivasa*
11.20-11.30	Discussion
11.30-11.50	Modeling the potential production of biofuel crops in India: An example for sugarcane production *Dr. Joerg Priess*
11.50-12.00	Discussion

12.00-12.20	Simulating the impact of biofuel development on country-wide land use changes in India *Dr. R. Schaldach*
12.20-13.00	Discussion
12.30-14:00	Lunch
14.00-15.30	**Session:**
	Biofuel Development and its Consequences on Land and Water (cont.)
	Chair: Prof. Joseph Alcamo
14.00-14.20	Land for food or fuel?
	Prof. N. H. Ravindranath
14.20-14.30	Discussion
14.30-14.50	Integration of Renewables and Efficiency into Energy Scenarios
	Ms. Indu Pillai
14.50-15.00	Discussion
15:00-15:20	Assessing the Potential Impacts of Large-Scale Biofuel Production
	Dr. J. Gururaja
15:20-16:20	Tea and Coffee Break
16.20-17.30	**General Discussion**
17.30	End of Day 1

Wednesday, March 8 (Day 2)

09.30-10.30	**Session:**
	Electricity Production and Its Consequences on Land and Water
	Chair: Prof. Dilip Ahuja
09.30-09.50	Will India's electricity production be limited by future water scarcity?

09.50-10.30	*Prof. Joseph Alcamo*
	Discussion
10.30-11.00	Tea and Coffee Break
11.00-13.00	**Session:**
	Electricity Production and its Consequences on Land and Water (contd..)
11.00-11.20	*Chair: Prof. Joseph Alcamo*
11.20-11.30	Social Impacts of Hydroelectric Reservoirs
	Prof. Shantha Mohan
11.30-11.50	Discussion
11.50-12.00	Modeling methods for assessing local/regional impacts of energy development on water and land resources.
	Prof. R. Seppelt
12.00-12.20	Discussion
12.20-12.30	The Future of Nuclear Energy Production in India: The Search for Suitable Land for its Wastes
	Prof. S. Rajagopal
	Discussion
12.30-12.50	Alternative Concept to NWDA's River linking Project to divert water from Flood prone North to Drought stricken south
	Mr. B. S. Bhavanishankar
12.50-13.00	Discussion
13.00-14.00	Lunch
14.00-15.30	General Discussion: Research Recommendations regarding Integrated Assessment of Liquid Biofuel Development in India
15.30-16.00	Tea and Coffee Break

16.00-17.30	General Discussion: Research Recommendations regarding the impact of Large Scale Electricity production on Land and Water in India
17.30	End of Workshop

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