Jatropha Seeds harvested from Train Repair Station after 10 months of Cultivation
in Erode, India

Case Study "Jatropha Curcas"

commissend by

Global Facilitation Unit for Underutilized Species (GFU)
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Results - Summary

Discussed single effects of the Jatropha System are demonstrated individually; a combination of the expected results remains a task ahead.

Results of past Jatropha projects in Nicaragua, Belize and India in terms of actual economic, social and environmental effects have been mostly not noticeable, poor and disastrous. They were more projection than reality driven. Projects have contributed to R&D, a better expertise and sensitisation on Jatropha System. However, accurate information from lessons learnt and their dissemination are insufficient.

Inconsistent approaches and exaggerated expectations concerning yields, input-output relations, resulting incomes and a lack of knowledge and economic considerations were dominant reasons for failures. Even though drought resistant, the plant requires water, sun and it needs nutrients and pruning, to produce fruits, fertilizer and biomass. Thus, each application has been mostly limited on either the “commercial monetary” side, “social effects” or “soil rehabilitation, reforestation and low-input” aspect. The likely potential of different “Jatropha and related systems” was partially proven but not integrated and brought into practice.

Possibly productivity with dominant genotypes is too low, to allow dissemination at present market prices without a reliable and specific framework created by Government

International cooperation activities on Jatropha should focus the Indian experience, where a major promotional Government program attempts to cover all relevant aspects of the system with a multitude of stakeholders from top to bottom. Active participation of National Governments is important to include bio-energetic issues into rural development to replace fossil fuels at present crude oil prices.

Conditions for multi-factorial results are presently better in India than anywhere else. A failure of an impressive “National effort on Jatropha” approved in March 2004, is likely to be a long-term setback in and beyond India, and beyond the Jatropha System.

The focus of cooperation should be laid on

- accurate data collection on multi-location crop and oil yields and their multifactor improvement, including intercropping and similar plants, as the key to sustained environmental, social and economic benefits of any “Jatropha system”
- independent and systematic monitoring of the National Program and the State Programs; discussion on instruments including a thorough economic, social and environmental evaluation and documentation of effects. It is important, that farmers and communities are not misled again into non-viable long-term private investments through low yields or insufficient market preparation
- design and discussion of an improvement of market based instruments for India to more effectively and sustainably integrate external benefits of this Jatropha effort
- support of open information centres that secure availability of relevant results

In the medium term, there is barely an alternative to a rehabilitation of degraded lands combined with an increased production of biomass energy for rural India on the horizon. Environmental, social, economic and directly related energy trends in India ultimately demand coordinated work with Jatropha and similar crops with combined benefits, in spite of limited and discouraging field results.

Helpful in India in the direct procurement and collection of information were short visits and discussions within a good week at the Agricultural University in Coinbatore, at CDRC in Erode, numerous Jatropha Farms near Erode, a Jatropha nursery connected to CDRC and a project of Indian Railways, SUTRA in Bangalore as well as Natural Fuels und the Ministry of Agriculture, Horticulture Department, in Hyderabad. The following incomplete picture does therefore not claim completeness but reflects only the level of information availability and networking found by the consultant within the time given inside and outside of India.

Deutsches Vorwort

Die vorliegenden Studie entstand im Auftrag der Deutschen Gesellschaft für Technische Zusammenarbeit (GTZ GmbH) gemeinsam mit UNIDO und dient der Erfassung bisheriger Erfahrungen bei der Förderung und der Nutzung der Purghiernuss (Jatropha Curcas) in Belize, Nicaragua, vor allem aber in Indien, im Hinblick auf die sozialen, oekologischen und oekonomischen Wirkungen..

Jatropha curcas gilt als Beispiel für eine vielseitige, aber nicht hinreichend genutzte Pflanzenart. Die Studie bestand aus einer Bestandsaufnahme vorhandener Informationen und einer kurzen Reise nach Indien, um vor Ort weitere Feldinformationen zu sammeln. Bisherige Ergebnisse sind ernüchternd, das neu aufgelegte Programm in Indien sollte daher dringend konstruktiv begleitet werden, um einen weiteren Rückschlag zu verhindern.

Trotz einer Fülle von Einzelinformationen gibt es kaum Überblicksdokumente, die die Aktivitäten in den einzelnen Ländern zusammenfassend darstellen. Die detailliertesten Einzeldokumente finden sich zu einigen botanischen oder verarbeitungsbezogenen Aspekten aus verschiedenen Ländern. Die umfassendsten Papiere wurden im Kontext des GTZ-Projektes in Mali erarbeitet, die Informationen zu Belize und Nicaragua sind knapp und punktuell und in vielerlei Hinsicht unbefriedigend, zu anderen Ländern liegen kaum ausführliche Informationen vor.

Auch die Informationen aus Indien, dem Land mit den mit Abstand intensivsten Diskussionen und Aktivitäten im Bereich Jatropha curcas, sind punktuell, zersplittert und geben keinen umfassenden Überblick oder eine Analyse der vergangenen oder gegenwärtigen Aktivitäten. Systematische Feldevaluierungen zu den bisherigen Aktivitäten liegen offenbar kaum vor. Die wichtigsten Dokumente sind Planungsdokumente und stammen von der Weltbank zum Maharashtra Projekt sowie von der Planungskommission zu geplanten Jatropha und Ethanolaktivitäten. Die einwöchige Reise nach Indien fokussierte den Süden des Landes und erlaubte das Sammeln von direkten Eindrücken und Informationen.

Hilfreich bei der direkten Informationsbeschaffung und –sammlung zu Indien waren Besuche und Gespräche bei der Agricultural University in Coinbatore, bei CDRC, der Besuch von mehreren Jatropha Farmen, einer Baumschule und einem Projekt der Eisenbahn in Erode sowie SUTRA in Bangalore, Natural Fuels und das Agrarministerium in Hyderabad, auch die telefonischen Kontakte mit der Universität Hohenheim und Reinhard Henning. Ausführungen erheben daher nicht den Anspruch auf Vollständigkeit sondern spiegeln den noch ungenügenden Stand der Informationsvernetzung in und außerhalb Indiens wieder.

Nachfolgende Ausführungen beinhalten daher subjektive Einschätzung aus Einzelinterviews, Vorträgen und ungeprüften Einzeldokumenten. Es gibt keinen zentralen Ort, wo die Informationen zu Jatropha zusammenlaufen, ausgewertet werden und an alle interessierte zurückgespielt werden. Einen Ansatz stellt die Homepage von R. Henning dar, die in Indien mit Interesse verfolgt und genutzt wird. Eine Reihe indischer Forschungsinstitute, u. a. Agricultural College in Coinbatore, tragen vorhandene Informationen zusammen; auch die Universität Hohenheim sammelt wichtige Informationen, ist jedoch aufgrund des Kooperationsabkommens mit Daimler-Chrysler in der Weitergabe noch etwas eingeschränkt.

Deutsche Zusammenfassung

Das Interesse der Entwicklungszusammenarbeit an Jatropha curcas rührt von seinen geringen Bodenansprüchen und der Trockenresistenz, die den Einsatz in erosions- und desertifikationsgefährdeten, niederschlagsarmen Gebieten und auch zur Aufforstung attraktiv macht. Jatropha Curcas produziert gleichzeitig nicht-essbare Ölfrüchte, die Purghiernüsse, deren Öl als Energiequelle alle Brennstoffe, insbesondere auch direkt Treibstoff für Fahrzeuge ersetzen kann.

Purghieröl kann auch, nach einer Veresterung mit Alkohol, als emissionsarmer Biodiesel verwendet und dem Petrodiesel bis 20% beigemischt werden, meist ohne erforderliche Veränderungen an den Fahrzeugen. Teure Importe von Petroleumprodukten können somit verringert und zugleich dem Klimaschutz in doppelter Hinsicht, durch Nutzung erneuerbarer Energien und Photosynthese gedient werden. Biodiesel kann gesundheitsfördernd, weil emissionenreduzierend, dem Diesel beigemischt werden und gleichzeitig Schmierstoffe ersetzen.

Reststoffe der Ölgewinnung stellen einen nährstoffreichen Dünger dar, aus dem als Zwischenprodukt auch Biogas gewonnen werden kann. Bei der Veresterung entsteht zudem Glycerin, das gereinigt kommerziell nutzbar ist. Holz und Schalen dienen als minderwertiger Brennstoff, auch als Fackel. Der Jatrophabaum gibt Vögeln Schutz und kann auch von Imkern genutzt werden. Einzelne Bestandteile können prinzipiell auch medizinisch, tiermedizinisch, für Kosmetik, Seife oder im Pflanzenschutz, auch zur Imprägnierung bspw. für Schiffe bei entsprechender Verarbeitung verwendet werden.

Giftige Inhaltsstoffe fast aller Spezies verhindern bisher die Verwendung als Nahrung oder Futter, und ermöglichen so die häufigste Nutzung als Feld- und Weidenbegrenzung, und damit auch als Schutz gegen Winderosion. Der im Vergleich zu anderen Bäumen mit nicht-essbaren Ölfrüchten niedrige Wuchs erleichtert die Ernte. Da die Früchte, auch auf Grund der geringen Erträge häufig als minderwertig angesehen sind, werden sie Armen, Frauen, Alten, Kindern und ethnischen Minderheiten zur Ernte überlassen, die diese gelegentlich als Brennstoff verwenden, verkaufen und somit ihr Einkommen aufbessern oder selbst zu Seife verarbeiten. Der resultierend niedrige Preis ist ein Argument für die Präferenz von Jatropha zur Biodieselproduktion.

Die vergleichsweise anspruchslose Pflanze gilt als gut für Trockengebiete, degradierte Böden, alle Formen der nicht-intensiven Nutzung und ist auch in Mischkulturen bspw. für Gemüse mit geringen Lichtansprüchen geeignet. Die Pflanze wird für Community Forestryprojekte empfohlen, da die Nutzenseite das Interesse der Dorfbevölkerung an der Aufforstung erhöht.

Die Pflanze ist jedoch kaum für einzelne Standort- oder Ertragsansprüche systematisch erforscht, vermehrt sich nach ihrem Export aus Mittelamerika in einer Reihe von Ländern auch eigenständig und wird in verschiedensten Wildformen „semi-domestiziert“ genutzt. Auch wenn gelegentlich Spezies in geringen Stückzahlen für züchterische oder Werbezwecke von einem Land ins andere verschifft wurden, sind Ansätze einer systematischen Züchtung auf bestimmte Merkmale spärlich. Die Universität Hohenheim hat mit verschiedenen in Indien vorkommenden Spezies erste Keimungs- und Ertragsversuche gemacht und eine große Bandbreite beim genetischen Potential, Keimverhalten und den Erträgen ausgemacht. Ein Bericht soll in den nächsten Monaten diesbezüglich veröffentlicht werden. In Erode wurde eine Gärtnerei/Baumschule besucht, die in Zusammenarbeit mit CDRC sowohl aus

Stecklingen als auch aus Nüssen produzierte Pflanzen herstellt und praxisnahe Anbauversuche macht. In Indien machte bei dem schlechtesten Projektbeispiel der Anteil der aufgewachsenen Pflanzen 2 % aus, Fruchterträge liegen häufig nahe null und werden bis 12.5 t/ha berichtet, so dass Ertragsprognosen schwierig sind.

In der Vergangenheit eher geringes Interesse von privaten Landwirten und Forstbesitzern erklärt sich durch mangelnde Nahrungs- und Futtereigenschaften, geringe Holzqualität und die vergleichsweise niedrigen Ölerträge der noch wenig bekannten Pflanze. Für die Gewinnung und Vermarktung als Treibstoff ist zudem eine Mindestinfrastruktur erforderlich.

Projekte der letzten 15 Jahre zur Verbreitung und Förderung der Nutzung von Jatropha Curcas insbesondere in Belize, Nicaragua und Indien auf insgesamt unter 10.000 ha gelten zumindest in großen Teilen der internationalen Fachöffentlichkeit zu Recht als wenig erfolgreich; bei nationalen Fachleuten in Indien werden diese bekannteren Erfahrungen in Nicaragua und Belize jedoch eher als Beleg für die Machbarkeit des Ansatzes gewertet.

Schwierige Projektverläufe haben zumindest in den amerikanischen Ländern verschiedene Gründe wie Vernachlässigung wichtiger sozioökonomischer und pflanzenbaulicher Faktoren, besonders überhöhte Erwartungen an Erträge und resultierende Einkommen. Euphorie, übertriebene Ankündigungen und ökonomischer Erfolgsdruck sind dabei in Nicaragua offenbar eine unselige Allianz zwischen Auftraggeber, Partner und Auftragnehmer eingegangen. Für die Projekte in Belize und Nicaragua gibt es nur wenige schriftliche, belastbare und quantifizierte Informationen, auch die Verantwortlichen äußern sich nur sehr zurückhaltend.

In **Belize** war das Projekt Teil eines gemischten Aufforstungsprogramms, sonstige Wirkungen von Jatropha Nebensache. Eine Infrastruktur zur Nutzung der Nüsse ist nicht vorhanden. Es sind keine Einkommenseffekte bekannt, die ökologischen Wirkungen bestenfalls vergleichbar anderen Aufforstungsprojekten. Die Pflanzen haben in den Aufforstungsregionen aufgrund der Konkurrenz um Licht zudem offenbar kaum Früchte getragen.

In **Nicaragua** wurden die Erträge mit bis zu 30t/Nüsse/ha über-, die Logik der Ökonomie und die unterschiedliche Qualität des genetischen Materials unterschätzt, so dass die Neueigentümer/Landarbeiter der aus Großgrundbesitz stammenden verstaatlichten Kooperative keine Einkommen aus den monokulturellen Pflanzenerträgen erzielten und die Pflanzen zum allergrößten Teil wieder ausgerissen wurden. Die Böden wurden nach wenigen Jahren statt durch Jatropha zur Nahrungserzeugung genutzt.

Dazu mag auch die Verunsicherung nach dem Regierungswechsel bezüglich der mittelfristigen Eigentumsrechte beigetragen haben. Die geplante Esterifizierungsanlage wurde aus Kostengründen und „mangels Masse“ nicht errichtet. Das ehrgeizige Programm, das >1% des nationalen Treibstoffs ersetzen sollte, mit Mindestkosten von 8 Mio. US$, hat zwar zur Bekanntheit der Frucht und ihrer Nutzungsmöglichkeiten beigetragen, muss aber ansonsten als das bisher größte Jatrophafiasko bewertet werden.

In **Indien** wurde die Pflanze in dem bekanntesten, von der Weltbank geförderten Maharashtra Aufforstungsprojekt im Rahmen von auch gemeinschaftlichen Aufforstungsmaßnahmen diskutiert. Aktivitäten waren zum Teil aus Nicaragua inspiriert, wo jedoch Niederschläge bis 2000 mm deutlich höher lagen. Eher dürfte jedoch die geringere Verwertbarkeit als Nutzholz, die wichtigste Einnahmequelle der Forstbehörden, größte Bremse gewesen sein. Zudem hatten die zögerlich gepflanzten Bäume aufgrund der Lichtkonkurrenz nahezu keine

Fruchterträge. Soweit Aktivitäten von Forstbehörden unternommen wurden, wurde Jatropha unter Aufforstungsgesichtspunkten bisher nirgends als wirklich geeignete Pflanze aus der Praxiserfahrung heraus benannt, vermutlich aufgrund ihres relativ langsamen Aufwuchs, der geringen Wuchshöhe und Holzqualität.

Eine Reihe kleinerer Projektansätze in verschiedenen Bundesstaaten Indiens (vor allem MP, Gujarat) im Rahmen von „Watershed Management", als Heckenpflanze oder als kommerzielle Frucht scheiterten weitgehend an geringen Frucht- und Ölerträgen und dem mangelnden Kultivierungsknow-how. In einzelnen Bundesstaaten Indiens wurden die Pflanzen von Bauern wegen mangelnder Einkommen zum Teil nach einigen Jahren enttäuscht wieder ausgerissen, zum Teil werden Früchte nicht geerntet. Im größeren Maßstab wurde die Purhiernuss u. W. bisher nirgendwo in Indien als Dieselersatz oder Erosisonsschutzmaßnahme eingesetzt. Am ehesten wird Purghier noch in Wassereinzugsgebieten und als lebender Zaun genutzt. Flächenknappheit, Brennholznutzung, Konkurrenz mit Drahtzäunen und die Wahrnehmung von Vögeln als Schädlinge haben letztere Funktion jedoch in intensiv bewirtschafteten Regionen zurückgedrängt.

Seifen werden in Indien überwiegend aus anderen Ölen, und selten im häuslichen Kontext hergestellt. Am nachhaltigsten scheint die Produktion offenbar in ärmeren Gebieten zu funktionieren, wo nicht-essbare Öle ohnehin gehandelt werden. Insgesamt wurden Angaben zu 1300 t gegenwärtig gehandelter Purghiernüsse in Indien bzw. der Produktion von <400 t Purghieröl Jahr für industrielle Zwecke gefunden, auf weniger als einem Viertel der ursprünglich gepflanzten Flächen. Im ganzen Land werden gegenwärtig vermutlich <1000 t Purghieröl produziert. Eine energetische Nutzung, über Demonstrationen und Forschung hinaus, ist im häuslichen oder dörflichen Rahmen oder auch als kommerzieller Biodiesel nicht bekannt.

Wirtschaftlichkeits- und Ertragsannahmen in Indien, die als Grundlage für das künftige Regierungsprogramm und deren Aktivitäten dienen, sind stark aggregiert, operieren mit fraglichen und überhöhten Durchschnittszahlen aus der Literatur und erlauben somit nur bedingt betriebswirtschaftliche Analysen. Die unglaubliche Spreizung und Widersprüche von potentiellen und realen Ertragsausagen zu Früchten, Nüssen und Öl wie auch der verschiedenen Kostenfaktoren für Produktion, Verarbeitung und Transport und auch die jeweiligen Handelsspannen erfordern dringend der Klärung. Es ist noch nicht erkennbar, in welchem Maße und mit welchem Aufwand eine systematische Züchtung und Verbesserung des Anbaus die Erträge erhöhen kann.

Im April 2004 wurde dennoch auf der Grundlage eines breit angelegten Berichts der nationalen Planungskommission ein umfassendes, und bisher beispielloses Purghierpilotprogramm (neben einem Ethanolprogramm) zunächst in acht Bundesstaaten für den land- und forstwirtschaftlichen Bereich mit 300 Mio. Euro/$ für 5 Jahre (Rs. 1500 Crores; Rs. 1 Crore entspricht 10 Mio. Rupees; 50 RS entsprechen einem $/Euro), und einer geplanten landbaulichen und forstwirtschaftlichen Anbaufläche von je 200.000 ha bewilligt. Dies stellt etwa das Hundertfache der gegenwärtig bebauten Fläche dar.
Das begonnene Programm bezieht sich nicht auf das weitgehende Scheitern bisheriger Aktivitäten. Ziel ist die Mobilisierung einer Vielzahl gesellschaftlicher Kräfte, die großflächige Verbesserung degradierter Flächen und Einkommen im ländlichen Raum und der Ersatz von 20% des indischen Dieselverbrauchs durch Purghierdiesel aus der Kultivierung von 11 Mio. ha Purghierflächen (!) und 13 Mio. t Biodiesel bis 2011. Die Anbauflächen sollen vor allem aus den etwa 70 Mio. degradierten oder ungenutzten Böden in Armuts- und Waldgebieten entstammen.

In der Verbreitungsphase sollen auch internationale Mittel aus Umwelt- und Klimaschutzfonds in Anspruch genommen werden. Das Programm wird seit Mitte 2003 diskutiert und hat daher hohe Erwartungen und vorbereitende Aktivitäten einer Reihe von Institutionen im Bereich der Forschung, Baumschulen, Pflanzungen und Veresterungsanlagen hervorgerufen. Bisher wurden >3 Mio. Setzlinge (für >1000 ha) produziert und eine Reihe von Pflanzungen bei privaten Farmen, Indian Railways und im Rahmen eines Daimler-Chrysler Projektes angelegt.

Die vielfältigen Ziel- und Nutzenaspekte der Pflanze sind eine Chance, deren undifferenzierte Addition ein Risiko. Chance insofern, als die Verbindung verschiedener möglicher Nutzungen eine makroökonomische Vorteilhaftigkeit ergeben kann. Schwerer ist es, die Nutzen bei den Bauern, den LandarbeiterInnen, der verarbeitenden Industrie und den Konsumenten monetär beizeiten „ankommen“ zu lassen. Risiko, weil die Addition der Nutzen den Bedingungen im „Feld“, der individuellen Ökonomie, nur in den wenigsten Fällen entspricht. Der Anbau von Jatropha stellt eine mehrjährige Investition und damit für Bauern ein Existenzrisiko dar, von dem sie sich nur einmal überzeugen lassen. Im Forstbereich wurde bisher der Nachweis einer möglichen Verbindung von Aufforstung mit Purghiererträgen nicht erbracht.

Die bisher geringe Nutzung der Pflanze hat damit zu tun, dass die erwarteten Vorteile für die jeweilige Zielgruppe bisher einzelbetrieblich nicht realisiert und monetarisiert werden konnten. Ein breiter Anbau kann vermutlich dennoch gesamtgesellschaftlich sinnvoll und wirtschaftlich gestaltet werden. Das geplante indische Programm kann eine richtige Maßnahme sein, um höhere Erträge zu ermöglichen und Kosten und Aufwände, Nutzen und Erträge sinnvoll zwischen den Beteiligten zu verteilen.

Zielgruppen, Arme, Frauen, ethnische Gruppen, kleine und größere Bauern mit degradierten Flächen, aber auch die für öffentliche Flächen Verantwortlichen, selbst Firmen wie Daimler-Chrysler, die in diesen Sektor jetzt beginnen neu zu investieren, werden sich unwirtschaftliche Maßnahmen nicht lange leisten. An den wenigen besuchten Standorten ist der Anbau der Purghiernuss für private Bauern gegenwärtig durchgängig nicht wirtschaftlich, weil Produktivität und Preis für die Vorarbeit der Kultivierung, die Nüsse und das Öl mit alternativen Einkommensquellen nur selten konkurrieren können, auch weil nötige Mindestschwellenwert für Ertrag, Züchtung, Vermehrung, Verarbeitung und Vermarktung noch nicht erreicht sind. Verbesserung von Boden, Wasserhaushalt, Klima, auch die Förderung ländlicher Einkommen und der Frauen im ländlichen Raum sind Nebenwirkungen, zu denen private Produzenten, Verarbeitungsbetriebe und Konsumenten erst bei adäquaten Preissignalen, die einen wirtschaftlichen Betrieb erlauben, beitragen werden.

Wo arme Bevölkerungsteile eingebunden werden sollen, die sich durch unmittelbaren Liquiditätsbedarf auszeichnen, wurde zu wenig beachtet, dass das Kultivieren von Jatropha über die reine Ernte hinaus erhebliches Kapital für Bepflanzung und Bearbeitung erfordert und bindet und zudem mehrjährige Planungshorizonte voraussetzt.
Zu beachten sind mangelnde Eigentumsrechte armer Bevölkerungsteile selbst an degradiertem Grund und Boden. Konzepte für die arme Bevölkerung zur Übertragung zumindest von Nutzungsrechten an öffentlichen Böden sind Voraussetzung für soziale Wirkungen über Lohneinkommen hinaus. Die Zahl der vorhandenen wilden und ungenutzten Jatrophabäume auf öffentlichem Grund wurde und wird vermutlich überschätzt.

Hauptproblem, trotz der faszinierenden Wirkungsvielfalt von Jatropha ist jedoch, dass die geringen „Faktorenansprüche“ nur das Überleben der Pflanze sichern, nicht jedoch die für eine wirtschaftliche Nutzung erforderlichen Erträge. Zur Erzeugung relevanter Ölerträge, des kommerziell wichtigsten Produktes, und der integrierten Nutzung verschiedener Vorteile bedarf es einer Mindestwasser- und -nährstoffmenge, hinreichender Lichtversorgung und auch gewisser Kultivierungsansprüche wie Beschneiden, Ausdünnen und der Entfernung von konkurrierenden Kräutern in der Pflanzphase. Zudem muss die Pflanze in fast allen Standorten einer züchterische Verbesserung und Auswahl durchlaufen, um Mindesterträge zu sichern, die dann in Verbindung mit geringen „Überlebensansprüchen" und einer geeigneten physischen und fiskalischen Infrastruktur eine breitflächige Nutzung erlaubt.

Die Vernachlässigung der erforderlichen Produktionsfaktoren dürfte der eigentliche Grund für das umfassende „Scheitern"- soweit man die gesetzten Ziele zum Maßstab macht - nahezu aller hier betrachteter „Jatrophasystemprojekte" in Belize, Nicaragua und Indien gewesen sein. Dabei ist die Vernachlässigung realer Wirtschaftlichkeitsfaktoren häufig zu Lasten der ländlichen Bevölkerung gegangen, die eigene Produktionsfaktoren zur Verfügung gestellt haben. Im Gefolge wurden dann auch soziale, geschlechtsspezifische und auch umweltbezogene Ziele verfehlt und in ihr Gegenteil verkehrt. Im indischen nationalen Programm wird dies nur zum Teil (beispielsweise 2 Bewässerungen pro Jahr) berücksichtigt.

Es ist dringend geraten, „trockenresistent" nicht mit „geringem Wasserbedarf" zu verwechseln, die Pflanze ist keine Sukkulente, sondern wirft ihre Blätter bei Wassermangel ab, lange nachdem sie auf Fruchtbildung verzichtet hat. Es wird davon ausgegangen, dass Bewässerung von Jatropha nicht auf Kosten des Grundwasserspiegels gehen muss, bedenkt man Wirkungen auf Boden, Mikroklima und Verdunstung. Durch mögliche Zwischenfrüchte muss durch den Bewässerungsbedarf auch keine Nahrungskonkurrenz entstehen. Ähnliches gilt für die Nährstoffe: Jatropha ist keine Leguminose, die häufig gelobten hohen Nährstoffgehalte des Pressrückstandes müssen nach der Ernte dem Boden in irgendeiner Form zurückgegeben werden. Dies ist nicht der Fall, wenn der Pressrückstand als Einnahme für Dünger in die Wirtschaftlichkeitsprojektion einfließt. Bei der Verbindung mit Aufforstungsprogrammen sind insbesondere Lichtansprüche zu bedenken.

Die realistische Einschätzung bzw. Sicherstellung adäquater Preis- und Ertragsfaktoren – die in Indien diskutierte Mindestbiodieselquote könnte dafür durchaus hinreichen - sollte daher mit künftigen Verbreitungsbemühungen im ländlichen Raum einhergehen und auch den wirtschaftlich-ökologischen Vergleich und die Kombination mit anderen Agroforstsystemen und (auch essbaren) Ölfrüchten suchen. Aufgrund der dünnen Datenlage ist noch nicht auszuschließen, dass Jatropha aufgrund zu geringer Erträge nicht die geeignetste Frucht in diesem Kontext ist. Deutlich höhere Preise der am Markt gehandelter Ölfrüchte sind ein Indikator für reale Produktionspreise und Opportunitätskosten. Koordinierte, multifaktorielle Ertragsbestimmungen und –verbesserungen und deren Auswertung sind wohl die wichtigste Voraussetzung, um weitere Fehlinvestitionen zu vermeiden.

Es ist wichtig, dass die auch für indische Verhältnisse beachtliche, jetzt anlaufende öffentliche Investition von 300 Mio. $/Euro für 5 Jahre - dies ohne einzelstaatliche und private Investitionen - in die Jatrophanutzung, und damit durchaus in Zukunftsfähigkeit, so verwendet wird, dass sich auch die Investitionen der ländlichen Bevölkerung, der Agroindustrie, von Nichtregierungsorganisationen und öffentlichen Stellen langfristig bezahlt machen. Dabei sollten die Projekte vor allem nicht wieder mit überhöhten Wirkungsansprüchen überfrachtet werden.

Der Ansatz zunächst sowohl für „Joint Forestry Management Comittees" wie auch für die kommerzielle Landwirtschaft offen zu sein, weist in die richtige Richtung und sollte eher als

Suchprozess verstanden werden. Technisch kann sowohl die Extraktion des Öls wie auch die Biodieselherstellung zumindest in Indien in Zukunft gemeistert werden, auch wenn die Probleme sicher noch unterschätzt werden. Schwierig sind auch hier die dem nationalen Programm zugrunde liegenden Kostenschätzungen, die nicht die zu erwartenden Produktions- und Produktkosten widerspiegeln.

Zur Verbesserung der für dieses Projekt nötigen Instrumente sollte die internationale Kooperation durch Finanzmittel, Beratung und erforderliche Detail- und Wirtschaftlichkeitsanalysen, im Bereich Monitoring und Verbesserung der Produktivität einen Beitrag leisten, um diese zukunftsweisende Entscheidung nicht durch irreale Annahmen, Klientelpolitik und Vorteilsnahme im „Überbau“ zu vertun und damit nicht zu einem Bumerang werden zu lassen. Zum gegenwärtigen Zeitpunkt ist die indische Regierung in diesem Programm für einen kritischen Fachdialog noch relativ offen, um vergangene Fehler in anderen subventionierten Bereichen nicht zu wiederholen.

Auch wenn die bisherigen Jatrophaerfahrungen ernüchternd sind, ist gerade in Indien kaum eine Alternative zu einer künftig verstärkten Bioenergienutzung erkennbar, wobei Alternativen zu Jatropha (bspw. Pongomia) durchaus vorhanden sind. Sich erschöpfende Erdölfelder und sinkende Prospektions- und Reservedaten für Rohöl machen deutlich über 35$ steigende Rohölpreis wahrscheinlich. Da Indien das ehrgeizige Programm explizit mit sozialen und ökologischen Zielen, auch mit anderen Energieversorgungszielen im ländlichen Raum verbindet, sollte die Chance nicht vertan werden

Wenn es gelingt, die verschiedenen Umwelt- und sozialbezogenen Faktoren auch wirtschaftlich zusammenzubringen, kommen realistische Handlungsperspektiven zustande.

1. The Jatropha System

The “Jatropha System” describes an integrated use of the different features of the Jatropha Curcas plant. Barely all effects and potential effects are being focused or used at any one site. Overall benefits and economies increase once full use of all plant features is made.

There are 4 specific features of the Jatropha curcas plant that explain public interest,

- low demand in terms of cultivation, water and soil quality with resulting suitability for degraded and unused lands and drought-prone zones
- non edible leaves and fruits, which stop trespassing (if grown in hedges) and browsing by animals, but can be used as a nutrient rich fertilizer and as a windbrake thus conserving soil humidity
- a nut, whose oil can be used or processed for any energy purpose, lighting, soap and other uses (pharmaceutical, varnish, plant protection)
- wooden parts, which can be used for reforestation, home of bee and bird, for charcoal or firewood.

Due to low and changing yields and low prices, the fruits are often not harvested by forest and farm owners, making them an optional income especially for rural poor and women. For the projects in India, Nicaragua and Belize focussed in this report soap making and the use as hedge is of lesser importance than its energy value, soil recovery and forestry issues. At different sites, Jatropha is being used by different social groups for different farming or forestry systems.

2. Belize

2.1. *Introduction*

Belize is a Central American country that lies in the Caribbean Sea and borders with Mexico to the West and with Guatemala to the South and West. This land nurtures a very rich environmental diversity best represented in the extended tropical forests that range in the inner uplands in the Southwest of the country. This rich diversity and forest share is being endangered by the high extent of the "Milpa" farming practised in the Mayan countryside. The growth of this "slash & burn" agriculture increasingly destroys a worrying large area of tropical forest of the highest environmental value. Reasons for the rising impact of this traditional form of agriculture are growing human pressure and fires, which get out of control.
Responsible for Jatropha activities in Belize is Janus Foundation, a Swiss NGO that works since 1995 on environmental and social issues. Main goal of its activities is to develop concepts for the sustainable land use to protect the tropical forest. The centre of its activities is the "Maya Ranch Reserve", situated in the Maya Mountains Northern Foothills region, near Cayo District, the Belizean Ecotourism centre. The "Maya Ranch Reserve" functions as a buffer zone between the populated areas and the inner highlands. It also serves as a research sample of the local ecology and experimental site for Janus Foundation projects. Examples of these projects are: development of agro-forestry systems, nurseries for local tree species, environmental education and identification of potential crop species, promotion and export of tropical ecological agriculture products a. s. o.

2.2. *Jatropha Projects in Belize*

The first project, where J. curcas was included, took place between the years 1997 and 2000. It was a reforestation project, where the goal was to duplicate, as quickly as possible, the closed canopy of the tropical rainforest in cleared forest areas using rapid reforestation methods.
In this context, the cultivation of J. curcas began in October 1998 in two pilot sites of Janus Foundation, using local plant material collected by surrounding farmers.
In the first location J. curcas was planted in rocky, poor soil with no irrigation and under full sunlight. The plants did grow under these conditions but the growth rate was very slow (they reached 1.5 m after two and a half years) and the fruit harvest was at this time almost non-existent.
The second location had better characteristics, with good soil, partial shade and more humid conditions as the first one. The plants did much better there, growing up to four m. and yielding a non-quantified fruit harvest compared to the first location in the same time span.

Meanwhile, a new project for the development of sustainable land-use of degraded pastures began in 2003, funded by the Organisation of American States.

In both projects, Janus Foundation had the scientific assistance of the Institute of Forest Botany and Tree Physiology of the Albert Ludwig University in Freiburg, Germany. The team of Professor Rennenberg researched the plants that Janus Foundation uses for reforestation (including J. curcas) in some parameters that should help optimise the reforestation strategies:
- leaf phenology
- performance of photosynthesis
- type of photosynthetic CO_2-fixation (C3, C4, CAM)
- contribution of di-nitrogen reduction to nitrogen nutrition
- root/shoot distribution of nitrogen reduction and assimilation

- water-use parameters during the wet and dry season

For each of these parameters functional groups of species were defined and reforestation strategies followed the natural abundance of those functional groups in primary forests.

2.3. Project Results

Nominally, the main goal of the reforestation with J. curcas, that Janus Foundation undertakes or has undertaken, is reclaiming the poor soils degraded by the slash and burn agriculture. But it is also stated that another goal of their projects is to develop economical activities in these projects in order to have a really environmentally and economically sustainable agro-forestry system. One way to achieve this is supposedly through the harvesting and selling of J. curcas seeds and oil. Nevertheless, if such enterprise is possible with the low yields expected in the tough conditions where J. curcas is planted is an open question that Janus Foundation has sadly not revealed.

2.4. Evaluation

Social Impacts:

- gender issues: not mentioned
- People without farmland: reforestation on Belize has taken place in forestlands, so it could be theoretically possible for people without farmland to pick the Jatropha fruits.
- Janus Foundation is trying to change the traditional farming system because it is no longer sustainable, so this represents a considerable socio-cultural impact, which, however, cannot yet be attributed to J. curcas

Environmental Impacts:

- Jatropha is planted on reforestation projects together with many other species
- The reforestation projects aim at stopping the erosion process in Belize
- There is some doubt, whether Jatropha is suitable to close the canopy of high tropical rain forests

Economic Impacts:

- Although it is mentioned that it will be attempted to use the oil of the Jatropha fruits, it looks like the yields will not be very attractive and that the plucking will not be easy in the Belizean high salary context.
- The plants do not receive any agricultural treatment to improve the fruit yield and are planted in locations with severe conditions that frequently are not easy to reach by anyone.
- Thus, Jatropha does not help to directly increase rural income, rural food security or energy in rural areas.

2.5. Conclusion

J. curcas is used here as a pioneer species for reclamation of degraded lands in a country with a large forest cover. In this context, it apparently has barely been viewed as an oil-bearing tree. Fruits would be hard to pick. Income levels in Belize are assumed too high to focus Jatropha oil for the rural population. The direct economic impact of this species, as far as very limited documentation allows concluding, to any target group is very small. Environmental impacts are the reclamation of eroded lands. Its comparative performance in reforestation is not documented. Environmental and economic value compared to other crops, crop families or other effects and options for the plant have not been found analysed.

3. Nicaragua

3.1. Introduction

Nicaragua is a small country in Central America that provided the background for the establishment of the first full scale J. curcas bio-diesel project with planned processing facility. The following facts show the favourable conditions that were meant to make Nicaragua a good start-up place for the development of a J. curcas oil industry:

- Nicaraguan economy is heavily depending on agriculture for export income, but export goods (mainly cotton and coffee) suffer a sustained fall of prices since the 80s
- Intensive cultivation of cotton left high extensions of agricultural land waste due to erosion, soil compaction and agrochemical residues
- Nicaragua has no own oil reserves and its importation is more costly than average because of the lack of adequate harbours for oil tankers and the poor transport infrastructure
- Sandinist revolution and post-sandinist Government enforced opposite politics with resulting decapitalization of agriculture and high rural unemployment
- J. curcas is natural to Central America, so environmental conditions would be expected to be suitable for Nicaragua

Local Jatropha varieties grow wild in Nicaragua and the species was already known and valued there for its pharmacological properties. The interest on Jatropha oil first began in 1989/1990 with an Austrian Development Project called "Proyecto Biomasa". This project was initially aimed at tapping Nicaraguan biomass energy resources while promoting treatment of industrial and household waste and wastewater, for example through agro industrial waste-feed biogas plants. In this context, J. curcas seeds were first looked at as an alternative biomass fuel to feed biogas plants. However the project manager, had earlier met J. curcas in previous projects in the Cape Verde Islands, where it had been tested as a diesel substitute. Thus, it soon seemed clear, where the true potential of the species was.

3.2. Proyecto Tempate

"Proyecto Tempate" (Tempate" being the local name for J. curcas in Nicaragua) began in 1991 and was up to now the first and only attempt to commercially cultivate J. curcas for its oil in Nicaragua on a large scale. Its main objectives were:

- to substitute fossil fuel with locally grown bio-diesel
- to supply raw materials for enterprises which produce edible oils
- to supply raw materials for enterprises which produce fodder concentrates
- to create rural employment,
- to reclaim wasteland and protect it from erosion

The project was financed by the Austrian Government, co-ordination and technical assessment was provided by the Austrian consulting firm "Sucher & Holzer" while the Technical University of Graz, Austria and Universidad Nacional de Ingeniería and Universidad Autónoma of Nicaragua provided research, mainly by intern students and doctorates. PETRONIC, the Nicaraguan national energy authority, was assigned to take up and manage the large-scale production of J. curcas bio-diesel and its distribution throughout the country.

The two main areas of activity of "Proyecto Tempate" were:

a) basic research on the physiology, genetics (although it seems that the only attempts at breeding were some trials with colchicines to try to get polyploid plants), chemistry of the J. curcas species and applied research on agronomic practices; oil extraction, detoxification and transesterification, this including the development of a one-step process for transesterification.
b) the establishment of J. curcas plantations and the construction of an oil processing facility to prove the feasibility of the production of bio-diesel in Nicaragua.

In 1992 field trials were established and maintained for three years in order to determine the most suitable varieties, edaphic and climatic conditions and tillage and planting techniques, and to record the seed and oil yields.
The results of these trials showed that the most promising region for the establishment of J. curcas culture was the area near León in the Pacific coast. The Departments of León and Chinandega in the North West of Nicaragua were also chosen for the first full scale plantation of J. curcas. This region is characterised by low and flat lands and hot subtropical climate (25-30°C) with a six month rainy season (from June to November) that amounts up to 1.800 mm (!) of rain per year. The soils are mainly of volcanic origin, and varied in both texture and fertility.

This region had the quickest economic development of the country in the 60s-70s due to the expansion of the cotton culture that reached up to 90% of the total export income of the area. These intensive productions lead in turn to an accelerated environmental deterioration of the region. Deforestation reached 100.000 has/year, one of the highest rates in Central America, erosion rose up to 44 t/ha/year, and a high contamination with insecticides, specially chlorinated hydrocarbons, was detected in underground water, cow and breast milk, the latter reaching up to 12 times the world average. Fertility of soilswas also critically low, especially micronutrients. The traditional rural agriculture was displaced to marginal lands. The drop of the prices of cotton in the 80s and rise in the prices of inputs forced the farmers to abandon the cultivation, and as the soils were so badly damaged, many of these lands were abandoned.
In April 1994, the nurseries for the large-scale production of J. curcas seedlings were created. In June after the first rains of the season, one thousand hectares of J. curcas were planted in these impoverished soils with a spacing of 3 x 3 m., reaching up to around 1.111.000 plants. The soils were first given a good preparation: sub soiling, rough and fine ploughing and fertilization.
The seedlings were planted either in polypots or bare rooted, that was favoured for ease of transport. The plants were to 60% of the Cape Verde provenance and 40% of the Nicaraguan provenance. The reason for this mixture was not disclosed.
Standard cultural practices in the project were: regular weeding (4 times a year), fertilization, surface ploughing and pruning. It was also experimented with surface and drip irrigation.
This surface was expected to yield 33.000 t/year of fresh fruit, which should account to 5.000 t/year of dry seeds, harvesting taking place throughout the rainy season. Productivity was expected to reach 30 kg of fresh fruits per year and tree, although the trees in the pilot sites yielded only 15 to 20 kg, as they did not reach full maturity. Individual trees in the plantations were monitored for growth and yield and showed a great variation, as the species had not been bred for productivity. There was no intercropping, but afterwards it was considered a good idea to encourage the cultivation of sorghum or beans between the rows of Jatropha in order to raise the standard of cultivation.

A critical point of this project was the farm management. The plant production was contracted to individual farmers (20% of the surface) and co-operatives (80% of the total surface), with extension officers watching over the payments to the farmers and the cultural interventions in the plantations. Further, the farmers and co-operatives demanded the project to take over their debts in order to work exclusively for the Tempate production. Thus, Proyecto Tempate took responsibility over the mortgage debts of the farmers from the National Bank of Nicaragua. For the initial establishment of the culture the farmers received further loans and were supplied with seedlings and machinery by the project. Land tenure was unclear in many cases, as the land was taken from large owners and redistributed among cooperatives during the Sandinista Government until 1990, when the new neo-liberal Government gave the former owners the opportunity to regain their former lands.

The oil processing plant with a capacity of 8.000 t dry seed/year (1.600 t bio-diesel/year) working 24 hours a day, was to be built in February 1997 in the town of Telica, Department of León, within 7 km of the plantations. The project management expected to increase the overall economic feasibility by selling the by-products, thus having alternative income sources. Actually, the cost of the bio-diesel was estimated higher than that of the petro-diesel (US$ 0.74 / gallon for bio-diesel against US$ 0.64/gallon in 1995). Selling of the by-products should make the whole plant economically viable. Fruit shells would be burnt in the plant to provide energy. The press cake was to be detoxified and sold as cattle fodder. Part of the crude oil production was to be detoxified and the oil sold for human consumption, too. The glycerol phase and other chemical compounds present in the oil were to be marketed as herbal insecticides as well.
This first plantation was supposed to create 840 temporary (6-7 months/year) and 45 permanent jobs and to supply 0,3% of the Nicaraguan diesel market to be increased to>1% in the following years. Further benefits were assumed: the reduction of greenhouse gas emissions, the reduction of erosion and reclaim of unproductive lands and improvement of the external balance of payment due to the substitution of imports thus saving in foreign currency.
In 1997, an International Symposium on Bio fuel and Industrial Products from Jatropha curcas and other Tropical Oil Seed Plants took place in Managua, Nicaragua, that yielded a preliminary document version of the research and projects done in Nicaragua as well other abstracts on J. curcas.

3.3. The Failure of Proyecto Tempate

During 1998, farmers detected a drop in the expected productivity of the culture, assumed to be due to a reduced work input. On a higher level, there was a political discussion about a new institutional arrangement for the project in the Nicaraguan Administration, while maintaining the long-term strategic energy policies of the project. This change of objectives, related to the position of the cooperatives, also had an effect on performance.

The project was aborted in 1999 (and all technical and management staff was laid off and thus could not be contacted now) due to the conflicts with the farmers, said to result from lack of control by authorities and land property rights issues. The producers were anxious to see results after two years, although maximum yield were only expected after the fifth year. Not seeing immediate benefits from J. curcas, farmers ignored their plantations and went back to cultivate traditional subsistence crops. No weeding or fertilising was done in the following years, and the harvesting was not done in the optimum maturation point, but rather when the fruits were already dry, in order to facilitate the work, thus - according to the project - further lowering the yields. They also used the loans for other uses and not for investment on the J. curcas plantations.

Other contribution said to be responsible for the failure was that the Austrian financial help decreased when it was most badly needed, that was, for the construction and subsequent operation of the oil processing plant. The financial assistance was mainly used for research purposes and decreased for the main phase of the project.

Another important point is that the economic evaluation of the project was overoptimistic. This comes mainly from the following reasons:
Even though some intense cultivation took place in the initial phases of the projects, the yields were estimated too high. Official reason was, because the pilot plantations were never allowed enough time to reach full production. Genetic research was done on species, but no high yielding cultivars were bred in any relevant number, so that the project had to rely upon natural-occurring clones for the planting material, leading to irregular yields. However, no quantification of actual yields seems to be available.
As well, the marketing scenario for the by-products of the oil processing was unrealistic, since detoxification of the oil or press cake was never accomplished in an economically efficient way, and no technology could be developed for the detoxification on full scale. Technologies and markets for the exploitation of other by-products were not sufficiently researched.

3.4. Evaluation

3.4.1. Social Impacts

- No references to gender issues (this topic was probably not considered in the project)
- People without own farmland: the farmers involved in the cultivation of Jatropha suffered a land property problem, as their present lands had been taken from big landowners during the Revolution. The following Government allowed the former property owners to reclaim their lost lands, so that farmers felt insecure and threatened about the actual tenure rights of the lands they cultivated. As it follows from the report, Proyecto Tempate did not consider this problem. As a former manager of this project pointed out: it would have been better to have the plantations first in public lands under Governmental control and then to expand it to private farmers and cooperatives.
- Indigenous knowledge: Jatropha is native to Central America and it is well known in the area for its pharmaceutical properties. However, the agronomic features of the plant were totally unknown for the farmers, who thought they could have good yields, and from the first years. This was said to be one of the main reasons for the failure of the project. Actual yields stayed for behind projections
- Other Social Issues: it seems that many social issues were not analyzed or taken into account in the project. The farmers were not really integrated in the project. It seems they were not enough instructed about cultivation practices for Jatropha, and that financing of the farmers and cooperatives plantations was badly managed.

3.4.2. Environmental Impacts

- Biodiversity: monocultural plantations on a large scale could theoretically have implied even a loss in biodiversity on a micro level, but they did not. The lands, where Jatropha plantations were established were so badly eroded and contaminated, that a natural reforestation process was extremely difficult. The provenances used for the plantations were not specifically bred, but only wild occurring trees and foreign strains (from Cape Verde) were selected in a few trials. The low level of selection and breeding also meant low and irregular yields. The cultivation of Jatropha implied that farmers stopped cultivating subsistence crops and had to rely on cash crops during that time with unknown impacts on food security and nutrition. When they rejected Jatropha, they went back to their traditional crops.

- The project, if successful, should have had a positive impact on land erosion, reclaiming eroded and contaminated lands. However, low quality soils were also a reason for low yields and economic non-feasibility of the project. Under such extreme conditions, stress on the shrubs probably had negative effects on yields.

3.4.3. Economic impacts

- The economic impact of the project upon the farmers (household income) was considerable: Proyecto Tempate supplied loans (that were grossly overestimated), machinery, fertilisers, and seeds, bought the whole production for a fair price and it even took over the debts of some farmers. But in spite of all this the farmers rejected to go through the initial stages of the project and to reach the full production stage of the crop, said to be from the fifth or sixth year onwards. When the project stalled, the farmers went back to their traditional farming
- Since Jatropha was grown as a monoculture and not as hedges, the farmers had to give up some of their subsistence crops in order to take care of Jatropha. For this same reason, it could not be integrated into the traditional farming systems. On the other hand, intercropping of vegetables on Jatropha plantations was also possible, but it was barely encouraged.
- The overall goal of the project was to make Nicaragua self-sufficient in terms of diesel oil. As such, it was not directed at providing energy to the poor rural households but at distributing bio-diesel as a substitute to fossil diesel in the national gas stations.
- The project was also not aimed at creating small-decentralised rural business units, such as oil mills and soap factories. The whole seed production was to be transformed into bio-diesel in the projects factories and the resulting bio-diesel to be distributed directly by the national Nicaraguan Oil Company.
- The project was expected to have an impact upon the national Nicaraguan energy market, making the country less depending on diesel oil and reducing the foreign currency drain. It does not look like any predictions or findings concerning other products and their marketing potential were ever done or taken into account.

3.5. Assessment

- the project failed, although conditions were promising
- the reasons are mainly:
  - Projections of yields and economic returns were largely unrealistic
  - The producers were not sufficiently integrated into the project or controlled, although they received relative large sums of money. The question of the land tenure was left open.
  - There was a strategy change in the goals of the project. Long term goals were mixed with short term ones due to political decisions. This change of goals had negative effects upon the project.
  - Cultivation was attempted under extreme soil conditions, not being able to mobilize sufficient work input on the part of the farmers.
  - The economic feasibility study was overoptimistic because it included detoxification of press cake and oil, which could not be realized.
  - Pilot and test plantations were insufficient in terms of realistic results. It seems that the project managers and funding agencies were too eager to come forward and show their results.

  - Funding (ca 8 Mio $) was also inadequately used, as it was mostly increased in the initial research stages and reduced when the processing plant was to be built
  - Other problems were general bad management, bad selection of producers, lack of control of the fields and lack of technologies.

- Nonetheless, this failure is not a sign of the non-feasibility of the project. The initial idea and the conditions were reasonable, but it is the project strategy, management and lack of analytical monitoring that caused a part of the failure. By spending more time with genetic trials, pilot plantations and a reasonable integration of the farmers in the project the result could have been different. As well, support and goodwill of the main stakeholders (in this case the Nicaraguan and Austrian Governments) are decisive. The Nicaraguan Government interfered in the strategy of the project and the Austrian Government only provided funding for a year at a time, making the production of quick positive results an unhealthy pressure upon project leaders.

- Technical Cooperation guidelines, which do not want R&D to be paid from cooperation funds, tempt or urge project planners to be overoptimistic concerning the state of new technologies and the level of adaptation and local refinement needed

- The change of oil prices of now > US$30/ barrel indicates that a similar project could become economically feasible and sustainable, if the question of actual yields and environmental sustainability of the monocultures of Jatropha are clarified.

4. India

4.1 Introduction

India is by far the country with the largest potential for Jatropha, the most advanced discussion, high-level decisions, biggest number and types of institutions involved and the broadest variety of experiences in the field of Jatropha, including most related issues and questions. India has the largest rural and agricultural population, severe problems with soil degradation, erosion and deforestation, and a scaring decrease of water supply and depletion of aquifers. At the same time salaries, farm incomes and food supplies are low, farm labour is mostly available; there is a need for an integrated farm management and an alarming overuse of resources. Rural energy and electricity supply is insufficient and further depleting resources, mainly through forest and dung use. Petrol-oil sources are said to deplete in 20 years at present consumption rates, with 70% being imported at present. India has almost one third of agricultural lands degraded and has between 50 and 150 Mio ha of not used, underused or degraded land, for reasons of and as a result of overuse, drought, erosion and deforestation.

There is an impressive history and diversity of farming systems, agro-industries and organisational structures. As well, there is an outstanding biodiversity (45.000 wild species of plant, 77.000 wild species of animals recorded) and its use for a variety of purposes in different regions of the country, even though still reducing at a rapid rate.

At the same time, India has decided upon internationally by far the most impressive and comprehensive National Program on Jatropha promotion; this in terms of level of political involvement, the broad and integrated objectives meant to be reached and the level of funds being made available.

Jatropha projects are documented to be carried out since 1991 with disappointing results. However, there is now more experience, better expertise about the strengths and weaknesses and success factors in India available, even though not yet well compiled. As well, Jatropha efforts have a much better Government backing now than ten years ago.

The wide variations of the situation in each area makes general statements on “India” unsatisfactorily and imprecise. A brief one-week visit and literature review does not allow a comprehensive picture covering the full variety of past and present efforts in this field. The following are incomplete information, impressions and conclusions:

4.2 Types of tree born oil seeds

The main tree born oil seeds with bio-diesel potential discussed in India are:

Jatropha curcas or Ratan jot
Pongomia pinnata or Karanj
Mahuca indica (mahua ori iluppai)
Simaruba
Neem

Apart from these crops there is another 20 plus oil trees with potential for bio-diesel discussed: Calophyllum inophyllum or Nagchampa, Hevea brasiliensis or Rubber, Calotropis gigantia or Ark, Euphorbia tirucalli or Sher. As well Boswellia ovalifololata, Coconut, Kusum, Pilu (50t), Jojoba, Jaoba, Bhikal, Wild Walnut, Unid and Thuma; are some of them. The different names in different Indian languages make it sometimes hard to identify each crop. However, little research on actual potential on bio-diesel of these crops in the frame of the present program seems to be existing.

There is a variation of oil contents reported between crops from 20% for Thumba to 70% for Wild Walnut. For Jatropha information on potential oil yields has a high variation as well between 20% and 60% of the seed. It seems that 25% oil recovery, at least below 30%, is more realistic with present species and technologies.

Government arguments to clearly select and prefer Jatropha for the National Program compared to other plants are the following:

low cost of seeds
high oil content
small gestation period
growth on good and degraded lands
growth in low and high rainfall areas
seeds can be harvested in non-rainy season
plant size is making collection of seeds more convenient.

Of all the above prospective plant candidates as bio-diesel yielding sources, Jatropha curcas is said by Government to be standing “at the top” and”sufficient information on this plant is already available”.

4.3 *Past Jatropha curcas Projects in India*

A number of separate activities on Jatropha have been implemented in different states, but not been well coordinated and assessed. The following results were found on past Jatropha activities and most important Jatropha areas, mainly from information, documents and workshop presentations handed over in Bangalore Hyderabad, and Coinbatore with information often based on field observations by Kareemula.

4.3.1. Madja Pradesh

In the area of Jhabua and Thesil there is some presence of Jatropha in tribal areas since a few decades. Within a state sponsored watershed management project Jatropha planting along contour trenches of hillocks for soil conservation and on farm boundaries in the lower areas was promoted in the early 90ies. After 5-6 years, there was 1-2 kg fruit per tree found, no information on acreage or oil yields. On farm boundaries, Jatropha growth in lower areas and their yields were considerably better. Seeds are plucked by tribal farmers with small stones, then sun-dried for 2-3 days and either bartered per kg against 2 kg of salt or sold for 4 Rupees per kg of seeds to traders. The traders sell them for 6.5 Rupee to oil-mills that transform about 25% of weight into oil. There are 25 t Jatropha fruits harvested, in the whole district an estimate 300 t.

4.3.2.Maharastra

In Cooperation with the Institute of Petroleum Deharadaun, who researched on oil content and engine efficiency, a group of twelve farmers in Nasik, Wester Ghats, and Ahmednagar, who earlier cultivated Eucalyptus went into 20 ha of Jatropha as an alternative, to compensate for the bad Eucalyptus market. On between 0.4 and 12 ha plantation each, the farmers planted 2500 plants/ha (2x2m), later at 3x3 or >1000 plants/ha. The Swiss Agency for Development Cooperation (SDC) organised some higher yielding varities from Nicaragua and Mali. As well, the Maharastra Cooperative Agro forestry Federation (CAFMS) together with the National Wasteland Development Board had introduced the plant on 1500 ha public lands together with ¾ other species like Albizia amara, Lucaena leucocephala, Acacia auriculiformis.

A decade later not one of the plantations was reported existing in the area. Some dropped fruits had wildly regrown but were not harvested. Reported reasons were opportunity costs of the soil, labour for fruit plucking and shelling and low quality plant material. On the community and forestland, Jatropha did not grow any fruits, assumingly because of the shade from the other trees. There had been an offer by a soap maker to buy fruits for the guaranteed price of 10 Rs/kg and supplied the seeds for farmers, however all 20 ha only yielded 2 t of fruit altogether. Farmer cleared their plantation and the marketing contract fell through. According to one source, over 50.000 acres of Jatropha have been pulled out by farmers in Maharastra and Andhra Pradesh

4.3.3. Gujarat

Gujarat is known for groundnut production, which laid the ground for a flourishing oil mill industry. This probably has helped the market to develop for other oil-bearing species like Mahua, Neem, Jatropha (mainly in Dahod) and Pongamia.

The agricultural market-yard of Dahod (two oil mills) is the largest in the state, with altogether 100 t of all non-edible oil seeds traded in this market per year. The Dahod mundy records the prices of Jatropha seeds. An illustration of the mean monthly average prices of Jatropha is given below.

Table 2. Mean Monthly SalesPrice of Jatropha Seeds at Dahod APMC (Rs/q)

Month	1998-99	1999-2000	2000-01	2001-02	2002-03
Annual average	676.36	606.83	549.00	576.82	781.57
Seasonal (Sep – Nov)	631	576	530	517	672.5
Off-season	693.375	617.11	555.33	590.11	825.2

Seeds are sold with some fluctuation between 5.3 (minimum) and almost 10 Rupees (in April) according to month and year. Jatropha prices are reported to be linked to the prices of edible oil seeds. Jatropha is used as a hedge/biofence in Dahod to some extent. As well, with the support of the local forest department, the farmers have raised Jatropha as a bio-fence plantation along the farmlands on the Godhra-Dahod road. In some cases, it was observed that the plants have matured and yield fruits. The fruit yield is around 0.75 kg/plant. Farmers collect the fruits and sell them to the local traders at Rs.4/kg.

4.3.4. Andhra Pradesh

Jatropha curcas was introduced into tribal lands in the state of Andhra Pradesh by the Tribal Welfare Department in 1993-94 and by the Integrated Tribal Development Agency in Utnoor, Adilabad district on 2400 ha at a cost of 10.000 Rupees/ha in three years. Seeds and fertilizer were distributed in kind; the rest of funds were released to the village Tribal Development Society. After three years of initiation of Jatropha scheme, an internal inspection made the following observations.

Particulars	Value(No.)
Sample Villages (No)	7
Area proposed (ha)	380.4
Area covered (ha)	312.0
Jatropha sown (No)	1358070
Plant Density (ha^{-1})	4353 (?)
Survival (%)	2.19

Adilabad district receives a normal annual rainfall of 1050 mm. The past 10 years had recurrent droughts in the district, which has forced the state to declare the district as a Drought Prone Area (DPA) district. The people initially came forward to raise Jatropha for mitigating the vagaries of monsoon failure. The prime reasons attributed for Jatropha failure in the district by the internal department inspection were:

- Frequent drought years after initial sowing of Jatropha; many plants died in the severe summer of 1996-97.
- Jatropha plants did not sustain heavy moisture in case of block soils and were rotten.
- Termite attack of Jatropha.
- No fruiting was seen even in fourth year of plantation. Hence, the farmers removed Jatropha and switched back to food crops.
- Jatropha has established only in very few patches along slopy and well-drained soils. These plants had started yielding in 1996-97 i.e. in the fourth year of planting.

After a thorough search for the areas brought under Jatropha cultivation, it was noted that Jatropha plants were seen only in a handful of minute patches. These plants when compared to the extent of about 2400 ha of plantations are miniscule. These were signs of fruiting, but on inquiry with the nearby farmers, it was learnt that the fruit yield was very meagre i.e. about 200 g per plant, when they were about 10 years old.

4.3.5. Remarks concerning reports on past Jatropha activities in India

From the above 4 main states roughly 5000 ha were planted, there were about <1000 ha still under Jatropha trees and possibly a maximum of 325 ha (at an estimated minimum rate of 1 t/ha) still harvested. There is information about a maximum of 375 T of seeds available altogether, yielding possibly 100 t of oil/a.

There are mostly reports on low yields going down as far as "no fruits found or harvest" at all on 1500 ha reforested area, to "100 kg seeds/ha" on farmland and "200g/plant" after 10 years of growth. The highest yield found reported in practice was 0.75 – 2 kg/tree. So with present rainfed planting practices a figure around <1t fruit/ha appears more realistic than almost 5t/ha assumed in official documents, real oil yield is rather 25% compared to 34% and prices at the oil mill reach rather >7.5 Rs. instead of 5 Rs. There are reports as well of trees uprooted by farms on lands up to >50.000 acres.

These figures, even though based on very limited experiences, field work and documentation, should be taken seriously in respect of the present much higher base figures for projections of national and state programs. There is no information on fertilization or irrigation in the past, or use of plants for rural pharmaceutical or plant protection purposes. The low yields and high opportunity costs are the key reason for failures; other reasons named were drought during planting, termites, water logging, hard work for plucking fruits, higher opportunity costs. It seems the acreages surviving have a long tradition of production and marketing and often belong to tribal or indeed very poor populations.

Survival rate of farm-based plantations seems to be near to none so far, even where a price of 10 Rupees was guaranteed. Use for life fences and planting in watershed areas seems to have some survival potential, apparently to a lower degree as a result of fruit yield. On farm boundaries water and nutrients can be more taken for granted as a side effect of other crop cultivation. Reports on actual operation of "Integrated Jatropha Systems" were not found.

Jatropha as part of reforestation efforts suffers from low to no fruit yields due to shade and limited growth rates. Number of trees per ha show a variation between 1000 and 4400 plants on agricultural land, in mixed forest areas considerably lower. As a rule of thumb about < 20 % of trees survived, and < 10% fruits and oil are being used. Yields from surviving acreage seems to have rather been close to 1t/ha (compared to 1-12.5 t/ha) or 250 l of oil/ha (compared to 1-1.5 t/ha. Use of the little oil produced in the past was apparently rather in industrial processing, less for energy purposes. However, at a price of 5 Rupees/kg of seed even 1 t of seeds/ha still represents 5000 Rupees or more than 100 minimum daily wages for women.

Because of low quantities and success rate, actual environmental, climatic and social effects have remained marginal, sometimes negative. Specific advantages for women in past programs could not be found documented. There were no specific reports on improvement of income to farmers or oil mills, or on improved rural or urban energy supply.

At the few locations, where a Jatropha market has grown or persisted, there was income sustainably generated for income from harvest, trade, wholesale and processing of Jatropha. However, it is not clear, whether investment made into Jatropha planting does pay off from this income.

As well, limited efforts in India (and other countries) so far have been sufficient as a base for a strong and joint national effort on Jatropha improvement and use.
From all figures and information gathered so far it can be assumed that Jatropha oil processing in India before a start of the National Programme was expected, was below 5000t/a, more likely below 1000 t/a. Even though it is hoped that the above statements are soon proven to be incomplete and overly pessimistic, it appears necessary to get a realistic picture on potential yields to avoid future frustration in particular of farmers, who sometimes invest their own land, labour and monetary resources.

4.4 Present Jatropha Activities in India

4.4.1. CDRC, Erode, Tamil Nadu

In Erode the NGO CDRC is promoting integrated farming and sustainable development since several years. A medical doctor is founder and head of this NGO, sometimes working as well as a veterinary doctor. He is using herbal medicines and promoting natural means of agricultural production, thus integrating agro-forestry, on-farm energy production and use of herbs for medicinal and nutritional purposes to support healthy and sustainable living conditions in rural areas. There is an impressive record of accomplishment on past development and promotional activities on sustainable agriculture, including commercial production of biodegradable food plates from banana leaves through local women.

One CDRC member is head of a nursery mainly for fruit and oil trees and ornamental plants. Since about two years, the nursery is focussing Jatropha in cooperation with Coinbatore Agricultural University, who is getting Government support for this purpose in preparation of the planned program and has since produced up to 500.000 plants (ca. 200 ha) from seeds and cuttings. Seedling production takes 60 days and cutting production 45 days, before being given to the farmers. There is no preference for none of the methods yet. 50 thousand seedlings went to Government bodies so far, about 40.000 to Indian Railways and roughly 400.000 to private owners (small and medium farmers).

The plants are given or sold to farmers and institutions, mostly on a contract base with yield, no-loss or buy-back guarantees. The nursery has its own, pragmatic but efficient trial fields to assess and select optimum genetics, with some plants imported from Nicaragua. Pruning patterns and alternatives, watering needs, shading limits, fertilizer needs and yield patterns on different species and families of crops are assessed. How to combat attacks by insects (webber) and other diseases (fungus, bacterial diseases), more frequent on Jatropha once grown as a monoculture with higher inputs, is quite practically worked on here as well.

The nursery in conjuncture with CDRC organizes training seminars for farmers, Government and Non-Government institutions and agro-industrial entrepreneurs. A pump, motorcycle, tractor and jeep have been tested, demonstrated and are partially running on plant oil for practical field demonstration. Soap is being produced for demonstration as well, however traditionally soap is rather produced from Neem, Coco and other edible or non-edible, higher priced oils in this region. Medical uses for Jatropha are barely known or applied, even though the head of CDRC is a medical doctor using a broad range of herbs for humans and livestock. Hedges, which sometimes used to be made from Jatropha, have been replaced by wire and concrete fences, thus using less space, work, reducing chances for dogs and humans to pass - cattle are barely grazed here, wild animals rather non-existent - and clearly showing property boundaries. As well, birds, feared to pick the seeds of planted food crops have been reduced by removing life fences.

Jatropha, in this region is mainly propagated for a few acres (1-10) of used or unused private, preferably fertile lands, mostly with irrigation facilities. The nursery propagates Jatropha as a partial but secure crop, at least in the first years preferably combined with rows of vegetables. One of the farmers visited owned 5 acres and used two out of them, allowing one acre to be planted with Jatropha. 50% of new farmers even now are estimated, according to the head of the nursery, to leave Jatropha cultivation after starting the crop.

Most farmers take from this nursery between 1 and 2000 plants (1-2 acres), some take 6000, around 200 farmers (the majority of farmers) took 50 to 200 plants so far. Two hundred twenty five plants were sold to Kerala the neighbouring State in the South.

Even though there is a 15% population without land and 20% of the land belongs to Government, 10% of the land is lying idle for different reasons and an estimated 10-15% are considered unsuitable, eroded, salty, swampy, dry or polluted. Production of seedlings rather targets average commercial farmers, sometimes using their idle lands, but only to a minor extent is targeting public wasteland. There was no case known where Jatropha targeted landless people in this district.

Farmers are advised to plant one fifth of their land with Jatropha and to water plants twice a week, at least every 5 days, to prune them and keep them below 2 m height for harvesting. Growers are instructed as well, to give mineral or preferably organic fertilizers one to three times a year.

Since water is becoming increasingly scarce in this predominantly fertile area, wells have to be dug deeper. Farmers have some interest to have drought resistant plants, even if to be watered, when water is available. Water is available, where wells and pumps exist, when Government periodically switches on 3-phase electricity needed for irrigation. However, present motivation of farmers and nursery to invest into Jatropha is the expectation of a major Government Program, assumed to increase oil and crop prices for Jatropha. There was a common understanding that based on present prices of 5 Rs kg seed, production can not be increased or even maintained.

Indian Railways bought 25.000 plants (for about 10 ha) so far, the biggest one sale for the nursery, and is prepared to invests 20.000 Rupees (400 $/Euro) per acre of their land for planting Jatropha. A site visited was conducted at the repair station for trains, where a few ha are very successfully cultivated with irrigation, 3 times a week, or even with constant drip irrigation through treated waste water from a waste water treatment plant operated at this station. After less than a year, these trees were already fruiting and harvested. Indian Railways has joined hands with the Indian Oil Company and plans to replace five, later ten % of its diesel demand with Jatropha. A test run was successfully conducted for a train from Amritsar to Delhi. Indeed, the discussion in Indian Railways is ongoing, whether to invest into line electrification or increase the fleet of diesel engines. Logistic in terms of planting and harvesting Jatropha along the railways will be particularly difficult.

Mainly from oral reports, it can be estimated that at present about one Mio. Jatropha plants (around 400 ha) are now cultivated in Tamil Nadu. There are about 3-4 other smaller nurseries that produce trees for planting as well. Numbers of interested parties are said to be increasing rapidly.
An important conclusion of CDRC is that low intensity farming with Jatropha gives too low yields to allow sustained cultivation of Jatropha. Land is too scarce in this region as well to allow landless people to get land for the cultivation of Jatropha, if not a specific program is designed for this purpose.

Purchase of plants (outside the house) is a pure men’s job: Planting of Jatropha is organised jointly with the men (who dig the wholes), women mostly do soil preparation and harvesting. Marketing, irrigation and processing (including soap making) is a man’s job. In the nursery, mostly women are responsible for plant care. In general women (99% of farms), do not own land in this area, even if inherited - by law women have the same heritage rights as men now, the land is then further divided into smaller parcels - it is mostly given to, taken by or at least controlled by the husbands or male family members. A major shift towards more women income, a bit different to tribal and forest areas, could thus not be observed beyond a common share, once agricultural and rural production is thriving. Not one woman had come to the nursery so far for purchase of plants, this - possibly as well for transport reasons - being an exclusive men’s job.

An important issue is rural energy supply, where subsidies on electricity especially for 3-phase water pumps is being stepwise reduced, partially by allowing only few hours a day or times a week water to be pumped. Constant price increases on electricity and other energy sources (kerosene, gas, dung, wood, coal) make farmers and rural households increasingly search for alternatives. Dung and especially trees (largely used for the dye industry) are becoming expensive, now said to be around 3000 Rupees/7.5 t truck and a fine of 500-600 Rupees to be paid for illegally cutting trees.

Contrary to most other trees and animals in India, Jatropha, possibly due to its short existence in the country, does not have any Goddess for protection so far, making it a bit less prone for appreciation and care. So far, there are few samples of new plants that have been adopted by goddesses in recent times; perhaps Jatropha could manage to make an exception.

The lowering of the water table, said to have gone down on average from 100 to over 400 m in the last 12 years in the region, is increasingly worrisome for farmers, who do rely for their regular cash crops on irrigation (sugar, cereals and vegetables). To build a new well may cost between 50 000 (900 foot) and 100.000 Rupees (larger diameter) according to size and depth. The average family here owns between 1 and 1.5 ha of land, allowing irrigation schemes to be mostly only organised and financed with groups of farmers.

In the best case and with full care theoretical fruit yields could reach, according to the head of the nursery, between July and October 1-5 kg fresh weight per plant and year. This yield should be possible with 3250 plants per ha, resulting in up to 15 t/ha or a maximum of 60.000 Rupees/year with 4 Rupees per kg guaranteed for seeds. However, so far this figure has nowhere been reached in practice yet.

A major share of income goes into labour wages, with minimum salaries for women being 40 Rupees, for men 80 Rupees. Opportunity returns for a ha of land are said to be between 20.000 and 60.000 Rupees here, with a remaining income starting from 1000 Rupees to 25.000 Rupees (sugar, cereals, tumeric) according to the crop, soil, season, productivity etc. . These crops however imply higher inputs, climatic and market fluctuation risks. Additional income through intercropping (tomato, bitter cord), for processing of the fruit or a premium for relative drought resistance and security for a guaranteed market, securing a minimum cash income, must be considered. As well, farmers can decide on harvest time, thus easing organisation of workforce in the peak season, since fruits do stay on the tree without harm for 2-3 months. The fruits, after late harvest have to be stored to dry for 2-3 days only. When harvested fresh, then 20-25 days drying time are needed. Dried fruits can apparently be stored for another 2-3 months without major oil content losses.

According to the owner of the nursery, the key to a success of Jatropha in this area, which is competing with other crops for land and labour, is that the price per kg of seeds has to rise from the present 5 Rupee level to 7-8 Rupees in the near future. A secure market and long term guaranteed cash income are just as crucial as high prices, if Jatropha is to be chosen for cultivation by rural farmers. A scheme for financing of the initial investment and for cash needs during the cultivation period and while not sufficient fruits can be harvested; will thus be important to a success of rather medium and long-term investments into Jatropha cultivation. There seem to be buy-back agreements of 14 Rupees and 50 Paisas per litre of oil available as well. Oil mills are available in Erode with an expeller machine, which needs a minimum of 6t seeds/day for operation, said to extract between 40-44% of oil from the seeds. As well there is a rotary system, said to only extract some 33%. The base of this percentage could not be clarified. Oil extraction machines and respective expertise have quite a tradition in the region, how well they are adapted or adaptable to Jatropha, is not sufficiently known. The nearest esterification plant is at Coinbatore University, some 80 km away. A larger esterification plant is discussed to be built in the area, mainly through private investors connected to the oil mill and to the mosquito coil sector, which apparently uses Jatropha for coils as well.

4.4.2. Agricultural University of Coinbatore, Horticultural Faculty, Tamil Nadu

The University is one of the nodal agencies earmarked for the national program and supported by Tamil Nadu State and Indian federal sources. Prof. Vadivel, the Dean, has done quite some sensitisation work in terms of workshops and training on a political level and has contributed largely to the information given in this report. Prof. Vadivel, is a strong promoter of Jatropha as a means of integrated rural development, bio-energy production and against "fuel terrorism".

The faculty and related institute operate a nursery and research trial fields with Government support on Jatropha. Some dissemination work to farmers is ongoing. There have been produced some 300.000 seedlings so far mainly for small farmers with one or two acres (maximum farm size in the region: 25 ha). Research is ongoing on spacing, selection and needed inputs.

Within the University, a small expeller (efficiency 32%) is operated. An esterification plant (250l/day or 80t/year) on a rural technology level has been designed, built and operated as well. bio-diesel is used for a demonstration motor with a generator to produce electricity.

This is interesting since information in India so far assume a minimum of 1000 ha per esterification plant. Because Government too wants to support sustainable rural industrialisation (following the examples of green revolution and dairy development), Prof. Vadivel encourages the model of self-help groups for further Jatropha cultivation, where 20-30 small farmer groups, have their own seedling and oil production and form the basis for one esterification plant each. Subsidies on seedlings would be 1.50 Rupees, said to represent 50% of production costs. Planting could be done during the "farm holidays". Since poor farmers do not get credits, and the minimum investment per acreis estimated around Rupees 10.000 per acre (25.000/ha), communal or cooperative organisation of farmers is a precondition.

Prof Vadivel reported about some larger producers of Jatropha that have entered into the crop recently like Mohan breweries, combining a windmill park with Jatropha plantations (100 acres rain fed, but the rainfall “is not cooperating”) and Eid Parry in the South of Tamil Nadu.

Coinbatore University is meant to become a Nodal Agencies for further support of Jatropha, once the planned Government project is approved. Farm incomes expected by Prof. Vadivel (37.500 Rupees/ha) are on the optimistic side as well. This assumes a fruit yield of 7.5 t /ha based on a canal irrigation, applied twice per month. Cost of harvest and resulting labour incomes are expected to be 5000 Rupees/ha.

As well, a guaranteed price of 5 Rupees per kg seed and 14 Rupees/l of oil needs to be secured. Agro-industries preparing for investment into farm contracts, esterification plants and expeller centres all assume 5 Rs./kg of seed as the base for the economic calculation. Fruit and seed yields seem to be sometimes not clearly distinguished. Yields are expected to be 1/3 in the first, 2/3 in the second and fully exploitable in the third cultivation year. Prof. Vadivel is now expecting approval of a program for farmers of 100 lakh Rs/block (200.000 $/Euro), to be designed for 350 blocks existing in Tamil Nadu alone.

4.4.3. SUTRA and Samagra Vikas Trust, Bangalore, Karnataka

SUTRA and Samagra Vikas are highly active in the environmental field in Bangalore. Both believe, and propagate, based on oil seed bearing trees and wasteland availability, that India could fully replace its diesel demand with bio-diesel from “low-input and low-cost” non-edible oil seeds alone. Based on field investigation and broad experience, SUTRA however, favours the taller, drought resistant Pongomia tree, with assumingly higher yields to be more adapted to different Indian climates and the most promising crop for rural energy to replace foreign exchange for petroleum products. SUTRA and Samagra Vikas jointly took up the task of preparing a draft of a national policy for bio-fuels with special emphasis on non-edible oils, which was widely discussed during and a National Seminar held on the topic in Feb. 2003.

Every 10 million hectare equivalent of tree cover are calculated to potentially give annually 25 million tons of diesel substitute and another 70 million tons of cake, which on fermentation can substitute an equivalent quantity of Indian coal. Forty million ha out of 120 Mio ha of unused lands available in India can thus completely replace current use of fossil fuels, both liquid and solid “at costs India can afford”. Pongomia only requires 350 trees per ha, thus “only” 12 billion trees are needed, a figure said to be close to the number of trees already planted on privately owned lands in India in the last 15 years. The figure used for diesel equivalent production per ha (2.5 t) is twice the average figure used by the Government for the present Jatropha program. From literature found yields of <1t/ha, near to the yields of Jatropha, are sometimes cited, but want confirmation. In any case, Pongomia is a larger tree, and thus suitable for reforestation, and has a long, indigenous history record in India. SUTRA and Samagra vikas feel, that Pongomia and 300 other oil seed bearing naturally available in India would be more suitable for a diesel program than the “imported bush Jatropha”.

Both organisations have done some impressive projects based on Pongomia oil in a number of joint village approaches with the support of the Ministry of Non-Conventional Energies by replacing all electric and fossil energy through Pongomia fuel, including at least one generator running in each village. However, with the end of the project and hand-over to other authorities, sustainability could not be fully proven yet, since farmers expect government to secure supply and maintenance for energy issues and have left engines and generators.

4.4.4. Ministry of Agriculture, Hyderabad, Andra Pradesh

Mr. Ranjit has the task to promote Jatropha in cooperation with the National Oil and Vegetable Seeds Development Board (NOVOD) and other agencies to farmers and agro-industries on behalf of the State Government in Andhra Pradesh. His role is networking, facilitation and to secure seedlings availability to farmers without cost. AP is considered to be a progressive country, more so than Tamil Nadu, in terms of horticulture, because it is the largest producer of many foods and vegetables. Mr. Ranjit said, the Government policy is not controversial between the political parties and a change of Government would have no impact, since there is a consensus for the need to reduce foreign exchange and pollution, while making productive use of wastelands and of the rural labour force in the country.

So far, there have been about 4000 ha cultivated recently in Andhra Pradesh, some places with 50-100 acres. In Nelo district, Government has allotted 2000 acres to plant Jatropha (Sager Sugars, Vijawada), based on a buy back arrangement of 5 Rupees per kg of seed, free planting stock (which is bought from nurseries for 2.30 Rs per seedling) and a credit for cultivation. There are 7-8 oil extraction companies that want to include Jatropha and about 10 other companies that want to do processing and marketing in the state. For farmers and plantations, the National Bank for Agriculture and Rural Development is to give credits at 8%, as well Government subsidizes Jatropha plants with 2.70 Rupees per plant. The present effort is the second wave of Jatropha promotion in Andhra Pradesh, the first failed in the early 90ies with no marketing facilities for fruits and oil in place.

4.4.5. Indian Railways

Indian Railways, owned by the Government of India, consumes with 4000 locomotives about 4 % of the country's total diesel fuel (40 million t) and plans to blend Jatropha oil with diesel and to plant Jatropha along 25000 km of the railway tracks and other wastelands to minimize petro-diesel consumption. Plans need to be understood against the background of a discussion for further capital intensive electrification of railway tracks. Indian Oil Corporation (IOC) will setup facilities for Fuel Oil extraction and supply it back to Indian Railways in 5, 10 and later 15% blends, in line with global norms and without asking for any modifications on locomotives.
A first successful trial run of a passenger train on green fuel was conducted in 2003 with the Delhi-Amritsar Shatabdi Express with a 4000 HP engine, which used 5% bio-diesel as fuel. bio-diesel is meant to enable Indian Railways to save on its rising fuel bill, while at the same time controlling pollution levels from sulphur and lead. “The plant can easily be grown on either side of railway tracks as it adopts itself well to arid and semi-arid conditions, demanding low fertility and moisture”. Petroleum Minister Ram Naik continues to states: “at the present price of Rs.4 per kg of Jatropha seed, the cost of bio-diesel is around Rs.17.50 per litre. But for large-scale production, the cost is expected to come down to around Rs.12. Unlike countries currently producing bio-diesel from edible seeds and agro-sources, we are planning to focus only on non-edible sources. Of these Jatropha has been found to be most economical".
A yield of 1.6 t of bio-diesel and 5 t of fertilizer from 6.5 t of seed is expected per ha land after two to three years. Several hundred ha have been allocated for testing. The bio-diesel will mean a considerable saving for the Indian Railways in terms of import and diesel cost, which is currently around Rs. 20 per litre. IOC is doing field trials as well to reduce imports of hydro-carbons by running buses doped with bio-diesel from Jatropha:” IOC wants to “bring in” the technology from abroad, since the plant “requires very little water or other inputs, which makes its cultivation easy and viable”. A site was visited (see 4.4.1), where a number of acres are cultivated with Jatropha since one year, however with constant, at one site even drip irrigation from a waste water treatment plant. Fast growth, healthy trees and some harvested fruits could be found in the field.

4.4.6. Daimler Chrysler Project, Gujarat, Orissa

As well Daimler-Chrysler, together with University of Hohenheim, Germany, and CSIR (Council for Scientific and Industrial Research) have started a public-private partnership project (600.000 Euro) to test and demonstrate feasibility of Jatropha bio-diesel on internal combustion engines. The project is probably the best-known Jatropha project and a major Jatropha promoter in India.

The two Jatropha plantations are located in different climatic regions of India; it can thus be determined, which local conditions are more advantageous for cultivation. It is planned, to plant Jatropha on 20 ha in Orissa (high poverty rate, low energy supply) and 10 ha in Gujarat (highly industrialised region) and to secure thorough field trials and research. Plantations will be handed over to the municipalities at a later stage.

Argument for the Jatropha plantation are anti-erosion, employment and climatic effects and “a good nut crop can be obtained with little effort” after two to five years, depending on soil quality and rainfall. The nut kernels “contain up to 60 percent of oil which can be extracted and transformed into bio-diesel fuel through esterification”. Daimler-Chrysler wants to have test runs on their vehicles with Jatropha and test their ignition performance throughout India. Daimler Chrysler just got the first sustainability price for their most environmentally friendly vehicles and lines of production out of 1500 competing cars by an eco test run independently by the Wuppertal based institute “Ökotrend”. The project seems to be in line with this effort to keep the lead on environmental and sustainability issues in the automobile sector.

CSIR and the University of Hohenheim have started to do a series of intensive scientific work on yields, plant species, water balance, CO2 balance, cultivation techniques. They want to import particularly high-yielding varieties from Mexico and Mali and propagate them through seedlings, cuttings and tissue culture. They have tested different seedlings from India as well and found a huge variation of sprouting patterns. They would want to isolate detoxified plants, oil and cake for fodder use to improve economies, if suitable financing would be available. Even though information is somewhat restricted, it would be important to have the yield figures, respective inputs and other results reported at the earliest possible.

4.4.7. Remarks concerning present Jatropha activities in India

The visit to India and discussions mainly in Coinbatore, Erode, Bangalore and Hyderabad were quite helpful to get a better understanding of past and present “Jatropha systems” in India. All partners were extremely helpful to provide information and to assist to collect some data within a relatively short time schedule.

The general impression was that there is quite some enthusiasm on Jatropha, however largely fuelled by a Government program, which promises to provide further funds and improve the economic framework for this approach. Even though quite some practical work has started backed by Government, information and hard data concerning long-term yields are still fragmented and based on very few sample experiences. Selection and breeding of improved Jatropha plants has started only very recently, and some promising results still have a very small experimental base to draw too many general conclusions on yield potentials at this point. Experiences that are more practical and systematic, comparative tests, field observations and reports are needed to design and redirect future activities. As well, other crops like Pongomia and the mixing of different Tree Born Oil Seeds should be integrated into comparative trials and discussions.

However, there was a consensus that inputs in terms of water, nutrients, labour, expertise and capital have to be intensified beyond the approach of a rain fed, low input and drought resistant crop, or otherwise, yield projections and respective returns need to be downgraded considerably.

As well, each target needs to be more clearly defined. If a renewable bio-energy crop is to be grown at expected productivity levels and competitive prices, then integration of rain fed, unsuitable or unfriendly lands and difficult social conditions cannot be taken for granted. Since social, reforestation or land rehabilitation issues are or need to be addressed equally or even primarily, partially because otherwise there is not sufficient land available for the project, then these objectives will create additional costs, which have to be accounted for separately. They will reduce productivity and barely permit dissemination at expected market prices; these issues need to be discussed more openly.

4.5. National Program on Jatropha

In April 2003, the committee on development of Bio-Fuel, under the auspices of the Planning Commission of India, presented its report that recommends a major multi-dimensional programme to replace 20% of India's diesel consumption. The National Planning Commission has integrated the Ministries of Petroleum, Rural Development, Poverty Alleviation and the Environmental Ministry and others. One objective is to blend petro-diesel with a planned 13 Million t of bio-diesel by 2013 (>>1000 times compared to the present world Jatropha cultivation and production), produced mainly from non-edible Jatropha oil, a smaller part from Pongomia.

For this end, eleven millions ha of presently unused lands are to be cultivated with Jatropha (for comparison: annual loss of Brazilian rain forest 2.4 Mio ha). A similar program was started with Ethanol production from sugarcane molasses, which is to replace 5% of transport petrol in the first phase. Announcements and discussion of this program have already now brought numerous institutions, private investors and some farmers to prepare and even start with work on a major Jatropha program. The move towards large-scale utilisation of Jatropha is thus mainly coming from the energy discussion, with its increasing environmental and health burden and foreign exchange cost; but as well from the Forestry and Rural Development Sector, looking for future income potentials. In March 2004 a first portion for a National Program on Jatropha was released with Rs. 800 Crore (160 Mio. $/Euro) to support cultivation of Jatropha on new fields and plantations of 200.000 ha. This is the first portion of a total program approved with a volume of Rs. 1.500 Core (300 Mio $/Euro) and 400.000 ha, to be realized within five years. The program intends to replace 5% of diesel consumption by 2006 with 2.6 Mio t of Jatropha bio-diesel produced on 2.2 Mio ha, based on yields expected by the Government.

To plant 11 Mio ha Jatropha, the program is to become a "National Mission" and mass movement and wants to mobilise a large number of stakeholders including individuals, communities, entrepreneurs, oil companies, business, industry, the financial sector as well as Government and most of its institutions.

In the first phase, within a demonstration project, the "viability of all components" is to be tested, developed and demonstrated by Government with all its linkages in different parts of the country, sufficient production of seeds and a wide information and education of potential participants and stake holders to allow for a self-sustained dissemination. The demonstration project consists of 2 phases, each with 200.000 ha planted in 8 states of 2 x 25.000 ha "compact area" each.

Cultivation shall be equally organised in forests through Joint Forestry Management (Tamil Nadu, Chattisgarh, Gujarat and Tripua) and on non-forest lands in agricultural farm plantations, sometimes mixed with other forest trees (UP-Allahabad; M.P.-Ujjain, Maharastra-Nasik, and AP in Telangana). Each state will have one esterification plant, which is meant to be economical from 80.000 t of bio-diesel onward, expected to come from 50 to 70000 ha each. Compact areas in each state will be further subdivided into 2000 ha blocks of plantation to facilitate supply of planting material, procurement of seed and primary processing through expellers.

Expected outputs from 400.000 ha are meant to be 0.5 Million t of bio-diesel, compost from the press cake, and massive generation of employment (16 Mio days/year) for the poor. The program is meant to assist to achieve emission standards and climatic targets approved by Government, to improve degraded land resources, and income to 1.9 Mio poor families at 4 families per ha, on a base of 5 Rupees/kg of seed sold.

For 2007, when the process is meant to move self-sustained, a scheme of margin money, subsidy and loan is planned to be instituted. Expansion of processing capacities is meant to run on a 30% subsidy, 60% loan, and 10% private capital basis. Additional support for mainly market based "Phase II" from 2007 onwards, is sought from International Funding Agencies, since the program addresses global environmental concern and contributes to poverty alleviation. Separate legislation on bio-fuels is recommended.

4.5.1. Rationale for the Program

India is sixth in the world in energy demand accounting for 3.5% of world commercial energy consumption. A large part of the population has no access to commercial energy from hydrocarbons at all. India's import of crude oil is expected to go up from 85 million t to 147 million t by 2007. Hydrocarbons, in India predominantly diesel (ca. 80 %, in Germany >40%) arre responsible for most of the transportation fuel in India; the transport sector is the most problematic as no realistic alternatives have been found so far. Overall transport crude oil demand was >50 Mio T in 2001.

In India, a larger share than in other countries is needed for transport purposes, in particular for diesel. Consumption is expected to rise at an annual 5.6% rate and by 65% until 2011. Domestic supply can presently satisfy 22% of demand and dependence on crude oil imports (>18 billion $/a) is increasing. There is a growing demand gap between production and consumption. At the same time, per capita consumption with 480 kg oil equivalent and 260 Mio people below the poverty line (>20% worlds poor) is quite low. Indian petrol reserves are expected to last for another 20 years plus. Rising and volatile prices and respective foreign exchange costs are one of the main risk factors of the Indian economic and social development prospects.

In Europe and the US blends between 5 and 20% of bio-diesel are used as well without engine modification, in the US so far a total of 400.000 m3/a. In France B5 (5% bio-diesel blend) is mandatory. Sometimes a low percentage additive for lubrification and sulphur removal from diesel fuel is used as well. In Europe bio-diesel is mainly made from rapeseed, sunflower, in the US from soybean and in Malaysia increasingly palm oil is being utilised. Nicaragua is cited as an example where Jatropha oil is used for bio-diesel to replace petro-diesel.

From a total of Rs 1500 Crores total Government contribution (300 Mio $/Euro) the major share (Rs 1200 Crores) is earmarked to be spent for nurseries and plantations. Legislation is to secure that use of B5 (5% blend) and successively B20 (20% blend) become mandatory all over India.

Bio-energy, as a replacement for transport fuel can be alcohol, bio-oil or bio-diesel. Bio fuels are to reduce negative environmental effects through lower emissions and climatic impacts. Local production of bio energy is projected to have a broad range of positive economic, social and environmental implications. Upgrading eroded and deforested land, creation of employment and income are part of the argument. The national program wants to stop soil and forest degradation and its environmental implications, generate employment for the poor, in particular for women, reduce climatic change and improve energy security.

Alcohol, mainly in form of ethanol is planned in India to be made from sugar cane directly or from molasses and to replace 5% of motor spirit for spark ignition engines. The alcohol program has started already. Bio-oil, without further processing, is only suitable for sturdy compression ignition engines (diesel), or asks for considerable motor modifications and maintenance. Therefore, the Indian Government focuses the processing to bio-diesel from plant oils. However, a direct use in rural engines, water pumps, tractors and generator sets to produce electricity are additional options to provide rural energy and energy security to the rural population.

Bio-diesel, considered an equal replacement of petro-diesel (with 5% less efficiency), can be made after transesterification from virgin or used vegetable oils (both edible or non-edible). It is meant to be produced in India mainly from Jatropha curcas and, to a lower extent, from other non-edible virgin oils (in particular Pongamia pinnata, called honge or pinnata, as well as Neem, Mahua). It requires little or no engine modification up to 20% blend and minor modification at higher percentage blends. The use of bio-diesel results in substantial reduction of un-burnt hydrocarbons, carbon monoxide and particulate matters. It is considered to have almost no sulphur, no aromatics and has about 10% built in oxygen, which helps to burn it fully. Its higher cetane number improves the combustion quality. Almost all present emissions standards are expected to be reached with bio-diesel, an important issue for WTO negotiations, even though the latest Euro Norm - if applied - are not yet secured.

While the country is short of petroleum reserve, it has large arable land as well as good climatic conditions, potential to produce biomass to be processed into bio-fuels. Demand of edible oil is higher than production, so edible oils, as mainly used in Europe and the US for transport oil, are considered not eligible. As well, edible oils are much more expensive, sometimes by a factor 3-5, in India.
Instrument to promote non-edible oils is hoped to be buy-back arrangements with oil companies to be put in place and mandatory use of bio-diesel blends. The Jatropha program is to be combined with other programmes of the Ministry of Rural Development to attract growers, entrepreneurs and financial institutions so that a "self sustaining programme of expansion takes off" on its own, with the Government playing mainly the role of a facilitator. Hence, for the expansion phase, the Government will need "to give only marginal financial support". The rural community will have the first right of access to the oil for its own use. Responsibility for availability of sufficient processing units will be with the Ministry of Petroleum. Studies have revealed that "direct and indirect impact of bio-diesel e.g. employment generation, balance of trade, emission benefits etc. are substantial and need to be accounted for" while considering the duty structure on bio-diesel and HSD.

However, a clear comparison between the yields and economies of different edible and non-edible oils, and why production of non-edible oils for farmers is expected to be more viable than of edible oils, has not been found inside the program argument. Duty structure is meant to be designed in a way that the price of bio-diesel will be slightly lower than that of imported petro-diesel fuel.

Jatropha curcas is considered most suitable since it uses lands, which are largely unproductive for the time being and are located in poverty-stricken and watershed areas and degraded forests. Jatropha is planned as well to be planted under the poverty alleviation programmes that deal with land improvements.

For the planned 13 Mio ha Jatropha, three Mio ha are to be identified in 38 Mio ha under stocked forest, 3 Mio ha hedge equivalent from 140 Mio ha of agricultural land and 2 Mio ha for absentee landlords since, Jatropha "does not require looking after and gives a net income of Rs 15000/ha". In addition, land comes from 2.4 Mio ha out of 24 Mio. ha of fallow lands; two Mio ha from integrated watershed development programmes; one Mio ha from stretches of public land along railway, roads, canals and 4 Mio ha from "other waste lands".

Agricultural plantations with medium to intense cultivation inputs and practices are not mentioned.

As a by-product the oil cake and glycerol are to be sold to reduce the cost of processing bio-diesel to par with the oil price. The sales cost of bio-diesel is expected to be very close to the cost of oil obtained for production, since the cost of trans-esterification is meant to be recoverable to a great extent from the income of oil cake (3-5 Rupees/kg) and glycerol (50 Rupees/kg). The cost of bio-diesel is expected to reach between 15 and 16.5 Rupees at an assumed price of Rs 5 per kg of seed and at 3.2 kg of seed for 1 litre of oil. “Thus the plantation, oil extraction and production of bio-diesel are economically feasible”. Overall oil bio-diesel recovery is expected to be 91% at an oil portion of 35%. There is a plant density of 2500 trees per ha assumed, in mixed forestry areas 2500 trees each are considered one ha. An average seed yield of 1.5kg/tree and 3.75 t/ha are expected corresponding to 1.2 t of oil /ha and 2.5 t of fertilizer. Bio-diesel is expected to be available on the market from 2005/2006 onwards. Work created of 300 “man“ days /ha would allow 550.000 people to escape poverty in the first part of the program. A transesterification plant is meant to cost Rs75 Crores ($/Euro 12.5 Mio; 1 crore is equivalent to Rs 10 Mio.), and procurement and expeller centre Rs 80 lakh ($/Euro 160.000; one lakh is equivalent to Rs 100.000).

There is some questions, whether processing costs will not be considerably more expensive, at least for any imported esterification technology, and whether local esterification has reached a stage, where mass production in the said price range can be made sustainable. .
Oil cake is discussed in the National Program to be used as feed in the future. However, present genotypes are unpalatable and poisonous and contain large shares of nutrients needed for soil recovery.
Glycerol might contain impurities and thus not fetch the present glycerol price on the market. In addition, at a 5% diesel replacement, glycerol would already cover present market demand five times. If the cake becomes part of the processing price, then additional fertilizer needs to be applied on the fields. Overall price and yield developments are hard to predict, but need a more cautious approach. Costs of seeds at 5 Rupees are expected to be beyond a level to allow a bio-diesel price at par with present petro-diesel prices, and too low to stimulate viable plantations for farmers.

4.5.2. R&D needs and responsibilities

A number of research and development needs have been defined by the program:

- Genetically improved tree species, to produce better quality and quantity of oil
- This includes tree improvement programs, identification of candidate plus trees, standardization of nursery raising techniques, (vegetative/seed/tissue culture)
- Scientific data for planting density, fertilization practices, planting procedures
- Technology practices for adoption at grass root level.
- Research on inter-cropping for agriculture, agro-forestry and forestry application
- Processing techniques including bio-diesel and uses of by-products
- Utilisation of different oils and oil blends including potential additives needed
- Blending, storage and transport of bio-diesel
- Engine development and modification
- Marketing and trade

Watering techniques, water and irrigation needs and wastewater use are not part of the program

There are some “micro-missions” or task forces planned for the different tasks:

Ministry of Forestry; JFMCs (planting on forest lands)

Novod (planting on non-forest lands)

Ministry of Rural Development (other land implementation);

Khadi Village and Industries Commission – KVIC (procurement of seeds and oil extraction)

Ministry of Petroleum (trans-esterification) and

Different Research Agencies (research and development),

All R&D activities are to be coordinated by a committee under the Planning commission.

Some of the institutions presently involved in R&D activities are the following:

Punjab Agricultural University (PAU)

Coinbatore Horticultural University with 250 l/day bio-diesel production facility

Institute of Petroleum (IIP)

Indian Institute of Chemical Technology (IICT)

Indian Institute of Technology (Delhi, Madras)

Indian Oil Corporation (IOC) with 60 kg/day bio-diesel production facility at Fardabad

Mahindra&Mahindra (works on tractors from Karanji bio-diesel; pilot plant in Mumbai)

4.6. Open Issues - Discussion

The present program is probably not only the most ambitious bio-diesel program ever launched internationally, but also one of the larger programs to jointly address energy needs, poverty alleviation and erosion control/deforestation. The present Indian program is attempting to integrate and combine crucial economic, social and environmental aspects at the same time. Past difficult experiences with Jatropha seem to be integrated in terms of naming all relevant aspects of Jatropha utilisation and integrating a large number of institutions, but not sufficiently reflecting yet the yield and cost side of past efforts. As well, there is not much comparison with alternative plants and energy uses found so far.

Program documents are believed to gravely under estimate production and transfer costs, needed inputs and time lag expected until production and processing and infrastructure is up to planned levels; at the same time, they overestimate yields and thus expected incomes.
Even though a program combining the issues of underutilized species and soils with energy issues should be mandatory in the Indian context, it is feared that over-optimistic projections may lead to a severe setback for both issues. Even more so, since farmers might be the ones who invest on a long-term basis into the Jatropha crop once again, without getting yields and returns as planned.
It is hoped, that the two preliminary phases with 2 x 200.000 ha will lead to figures that are more realistic and will result in a more accurately quantified approach, without inducing a halt of efforts. Costs, yields and inputs discussed in the program planning are sometimes contradictory, and all possible positive and maximum effects, in this program as in most other Jatropha approaches, are unconditionally added together.

Average oil yields of over 1 t/ha asking for seed yields close to 5 t/ha can most likely only be attained on medium soils with irrigation, pruning, fertilization and sufficient sun exposure. However, with the plant material presently available and past experiences it remains questionable whether similar yields are even then realistic on a broad scale in a short term. To create high yielding varieties on a million ha scale, a lot of time-consuming breeding and selection work has to succeed before. Figures and information on high yields seem to be coming rather from hearsay from remote countries like Nicaragua, than from many Indian plantations in the field, which have been evaluated and described. Marginal lands, lands with limited access and infrastructure, tribal and forestry land must be expected to have lower productivity, at least in the initial phases. There is no confirmed information that Jatropha indeed fits into reforestation efforts, which combine Jatropha and oil production with other higher growing forestry tree crops. According to the available information, higher crops shade Jatropha to a degree that fruiting becomes marginal.
Urgently, dry and wet weight, fruit and seeds yields will have to be more clearly distinguished in all reports to allow any reliable economic calculation.
To attain yields envisaged, higher inputs are needed which in turn result in higher production costs and thus higher oil prices, closer to present prices of edible and non-edible oils between 20 and 70 Rs. per litre, instead of 15 Rs. to be guaranteed now.
As well, processing cost for expeller and bio-diesel production will be higher than assumed. If the bio-diesel production is to profit from sale of the nutrient rich press cake (at 3-5 Rs./kg, which is almost the same price as assumed for the whole fruit), to keep the price of processing low, then inputs into nutrients and fertilizer on the Jatropha fields will have to be further increased.
Glycerol, if indeed purified to needed quality levels, would flood the market, reducing the actual market price of Rs. 50/kg (1$/Eruo) considerably.

In terms of economies, there is a big difference, whether to plant Jatropha or just to harvest the fruits from existing trees, which is rather the basis for the present estimated national price of Rs5/kg. If cultivated on a more intense scale, increases of production cost and possibly more plant diseases and insect attacks will have to be expected.
More discussion and analysis are needed, why other non-edible and edible oils are presently so much more expensive than envisaged Jatropha oil costs. Whether productivity gains and economies of scale will really compensate these points in a short period, remains questionable.

To achieve the ambitious national goals presently envisaged a well-coordinated and much larger input will have to be mobilised and more price incentives will have to be secured for farmers, processing companies or wholesalers on a reliable basis. For this, economies of by-products, reforestation, soil improvement, social effects, availability of rural energy, foreign exchange savings, and emission related and green house gas effects need to be quantified, priced and attributed separately, to reach at market prices for each step, which allow viable private investments at different locations. Addition of each maximum positive effect possible might be necessary to get a national program approved, however, it could turn into a boomerang once private inputs are needed.

High costs and environmentally detrimental use of dung, charcoal and wood for rural energy supply, for example deserves further attention to allow better uses of the energy produced and to improve economies of the overall approach. As well, shortages of energy for watering, not only shortage of water itself, is presently a major reason for limited rural productivity and income. Whether a massive increase of irrigated fields for Jatropha can be justified in view of its water balance, needs to be clarified scientifically.

There is a range of options for optimisation, by using and intercropping with other non-edible oils, edible oils and vegetables, better use of by-products and other income sources (i.e. soap, medicine and bee keeping). In spite of many shortcomings and insecurities of the present argument in India, there is sufficient good justification for an investment into a rural non-edible oil program at this stage, even with more realistic figures and projections.

Most urgent is the need to collect scientific data on the fruit and oil yield pattern at different sites and their agro-inputs needed. There is undoubtedly a big margin for selecting and breeding crops with higher yields of suitable oil, including the use biotechnology, tissue culture, etc.

The picture in India is contradictory, diverse and complex and thus statements tend to simplify due to the enormous range of situations, statements and institutions involved. In any case, the often cited "Jatropha System", solving environmental energy, import, employment, poverty and gender issues at the same time, needs to be subdivided into different "Jatropha systems" with empirically based reliable cost, yield, social, economic and environmental projections. Time span between policy planning and actual implementation, yields, resulting market prices and needed inputs have to be brought into a realistic balance to secure a sustained program continuation.

Bio-diesel needs an attractive price for raw material production and processing, but as well an attractive price to compete with petro-diesel and rural energy sources. As long as alternative incomes from other crops, labour and even reforestation efforts persist to be considerably higher, the program is bound to stagnate or even fail fully due to a lack of oil supply. If other targets as soil improvement, reforestation, poverty alleviation etc. are to be combined with commercial bio energy production, they need to be accounted for and brought in line with market based economic cost figures, to reach at prices that allows production and consumption on a sustained basis. To this end, transparent, long-term market regulations or subsidies will have to be designed and established, as is done in many other countries. For an increase of oil production alone a guaranteed, mandatory and controlled use of Jatropha based B5, B10 and B20 would be sufficient.

4.6.1 Jatropha Systems in India

Jatropha is not considered an Indian crop but was introduced from Africa and Latin America. There is a variety of "systems" where Jatropha has been used. It is said that there was some habit in the past of using Jatropha as a life fence, however this use has apparently been considerably reduced with wire fences, land division and pressure on land and shrubs. To what extent plants still exist for this purpose, is only known to a small extent. In life fences fruits are only sometimes collected, used or sold, the extent is not known. In any case, the fencing around fields apparently gives better yields than other system so far, probably because of "left" excess inputs (water, nutrients, cultivation) resulting from and meant for the main crop.
There is a long tradition with oil bearing trees and a large number of rural oil mills for other oil fruits in the country, which sometimes are used to process Jatropha as well.
However, soap is mostly made from other oils, which apparently fetch better prices. There is one large industrial manufacturer known using Jatropha as base for his soaps and products. Soap is mostly made by rural manufactures based on a long tradition and high density of rural manufacturing companies, not home-based. There are cases reported, where Jatropha was grown on commercial rain fed and irrigated lands, on degraded lands and in forestry or joint forestry management areas. There are, however, few cases reported of intercropping with food or vegetable crops.
Present efforts in the frame of the national program leave the cropping system open. The focus is on underutilized lands, but seems to expect a rapid increase of production through monoculture planting of Jatropha on agricultural fields, and mixed forestry cropping in forestry areas.
Cases where full use of the different benefits was made in an organised manner have not been found reported, besides discussions about potential benefits.

4.6.2 Processing of bio-diesel

Government calculations assume a minimum of 100 ha Jatropha for one expeller and collection centre and 1000 ha for one esterification plant. Making oil from seeds has a long tradition with rural oil mills in India, however with potential for adaptation to Jatropha and improvement of efficiency. Processing raw Jatropha oil into bio-diesel only exists on a small and pilot scale in India, meant for rural industries. For large scale, imported technology is expected to be applicable.

Trans-esterification converts triglyceride (oil), when combined with alcohol (methanol, ethanol) into a fatty acid alcohol ester (= bio-diesel >90%) and Glycerol. The process takes place at 60-70 C and asks for the glycerol to settle and the alcohol to be recovered by distillation. Ester blends are assumed to be stable and not to separate. Flash Point, cloud Point and viscosity are comparatively high, crystallisation to be expected at temperatures below 0^0 C. Plugging of fuel lines and filters may become a problem in the northern hills of the country. Calorific value is sometimes believed to be 80% of diesel, sometimes 95%, apparently partially due to higher density of Jatropha diesel and reference used. Jatropha bio-diesel can be stored like petroleum diesel fuel, and mixed with petrol-diesel - some problems with stability are reported though - hence, the Government believes that there is no separate infrastructure needed. However, transport cost from and to remote areas may be a major issue. There are altogether 2500 seed collection and oil expelling facilities foreseen to be installed. The KVIC´s (Khadi and Village Industries Commission) with their long experience on rural industrialisation and rural infrastructure, are assumed to play a key role for these issues in the rural context.

Handling, transport, storage, drying, blending, engine conversion and processing of seed and oil will ask for considerable effort in the medium term. This applies as well for quality control, where possibly the new EU norms are to be adapted. The present approach, to leave development and capacity building issues in this field to the private sector, but give market based incentives and loans, appears appropriate. However, framework regulation and cost analysis should remain a Government task to assess and understand the real potential and shortcomings of economies of the overall program.

4.6.3 Plant Oil Market

Globally there are about 100 Mio t plant oil produced per year, with a quarter soybeans, a quarter palm oil followed by sunflower, groundnut, cotton, coconut and olive oil. In India, 6.7 Mio. t are produced (mainly from 14 edible oils led by mustard, groundnut, soja, coconut and rice, 2001). However all oils together produced in India are not sufficient for home consumption, cheaper palm oil has to be imported from the international market. Overall ethanol production for comparison is 1.3 Mio t.

The present total non-edible oil production in India is estimated to be around 100.000t/a or 1.5% of total oil production. From other sources and field reports one tenth of this seems to be a more realistic figure. Presently the oil is available in limited quantities and on a seasonal basis only. Out of non-edible oil production, around <1% or <1000 t of Jatropha could be traced so far. One important reason for the Government preference to use non-edible oils to replace diesel is the lower cost (at present). There is little indication and argument that this low cost can be maintained, as soon as not only the cost for harvesting but also Jatropha production costs have to be accounted for, besides transportation and processing. High price sensitivity and volatility, with higher demand resulting in higher prices, should be expected with the massive market intervention planned.

4.6.4 Institutional Set-up

There is a well thought through institutional structure planned for the program. Coordination of the Program from the National level as foreseen is a good basis to get all relevant public non-government and private stakeholders from Rural Development, Agriculture, Environment, Forestry, Energy and Industry involved. Different micro-missions take national responsibility for different tasks. Good interaction and coordination between all active regional and hierarchical levels is necessary, in continuation of the planning phase of the program. A strong involvement of local organisations in the decision making process is just as important for a good coordination as involving all relevant sector Ministries. A good and open inter-institutional cooperation during program implementation will be the key to successs. Seminars, including trainer seminars as planned, are needed to establish a basic knowledge on the different levels of intervention. It is hoped, that activities will indeed be open and transparently documented and discussed to allow necessary corrections and synergies immediately. A focal point to collect all information should be built up and open to the public.

4.6.5. Other Uses of Jatropha

There was no report on results of actual or traditional use of the plant for medicinal or insecticide purposes found in any of the projects looked into, even though medicinal value and even use by some companies seems to be undisputed and chemical companies are one of the main present buyer of the Jatropha oil produced. Since India has an intense tradition of using medicinal plants, the reason might be Jatropha´s short existence in India. There is no exact date named for the introduction of Jatropha, possibly less than 100 years ago. Even a medical doctor visited at CDRC, who intensively uses herbal medicine for humans and livestock, did barely apply Jatropha. Patents on Indian medicinal plants have already been granted by the US patents office on different crops, out of these two for Jatropha. A more detailed analysis however, of use and sales to industries for tanning, candle making, soap manufactures, pomades, ship industry (varnish) chemical and cosmetic industry for different non-edible oils should be done and documented. Individual household use or processing into soap seems to be rare in India. There used to be some application of non-edible oils for light and cooking in the past. Considering Jatropha for bio-diesel production only without using synergies from other application, is not thought to be wise by any of the stakeholders, even though any practical use seems to be very limited at present.

4.6.6. Social and Gender Issues

Women have been users of a multitude of indigenous herbs, fruits, trees, and animals and are directly interested to keep biodiversity alive. They often tend to have a detailed knowledge of the different species in their environment. The loss of habitats affects the most underprivileged people, often women. Home gardens and backyard plots are often used as experimental plots using diverse wild and indigenous species. However, a very active role of women in the push to promote Jatropha could not be detected in none of the projects so far. Most information on the role of women in Jatropha activities comes from Erode. At least here, it seems that gender specific effects of Jatropha cultivation are marginal and effect proportional to stable division-of-labour patterns. In those forested and tribal areas, where Jatropha is found and collected freely, Jatropha may be a source of additional income for the lowest income groups. For tribal areas a specific "Jatropha policy" might have to be adopted together with the respective tribal self-help groups and authorities.

Training, education and an intensive awareness campaign, including training manuals in local languages are meant to be integrated into the Government program and will be important for a successful application. There were reports found as well on a 1000 women training in Jatropha in Pudokottai under the heading of new horticultural crops, assuming promising yields and labour options. Integrating Women's Self-Help Groups to organise them to collect fruits from public wastelands within the National Program is expected to help rural women significantly.

The figure of 300 additional person days employed assumed per ha and year seems high and can realistically only be paid for, if high yield projections materialise. Labour intensity of Jatropha compared to other crops was nowhere found discussed; undoubtedly, it is higher than in idle fields. Of course if an additional 400.000 or even 14 Mio. ha are planted indeed, then obviously effects on rural employment would be significant.

According to the National Program, processing of non-edible oilseeds requires simple-technique oil mills, oil expellers and solvent extractors, which mostly already exist. Many of them are not having sufficient work at present, apparently due to liberalization of imports of edible oil, in particular of palm oil. By increasing the availability of bio-fuel oilseeds to be processed with the existing local equipment and requiring no or little modification, rural

employment also would increase. Oil mills are often on a small village group scale and highly decentralized unlike petrol oil refineries and gas facilities. A modern, but appropriate village expeller is said to cost Rs. 20 lakh (40.000 $/Euro) and can employ up to 10 persons for a capacity of five t seed per day.
For past programs, better field investigation to determine social effects on a micro level would be needed. So far, it seems that private farmers, who have followed the advice to make their land available for Jatropha have rather experienced losses, because they have discontinued activities. The same is assumed to apply for labourers, women and children, who work on those fields, since only out of a tangible income to farmers wages can be paid to them: In the agriculture sector, only increased farm incomes would allow social improvements. In agro-forestry, Jatropha without significant yield or use of fruits cannot be expected to have had major positive social effects.
In the nursery visited in Erode, 4 women found a constant employment that helps to feed their family. Since nurseries are the backbone of the planned dissemination program, additional creation of employment for women can be expected here.
Jatropha is largely planted and harvested by women; but division of labour is similar to many other crops. The specific advantage to children, women and elderly and poor people is partly due to the low value of the crop. With higher crop prices, "free" collection of fruits might be reduced, and the advantage then either reduced or increased up to the level of the salary paid.
A major factor is the intermediaries and wholesalers involved, who sell the seeds to the oil mills and sometimes increase prices by 50% or even double them. Which share of this cost results from transport and handling, losses and equipment, and whether the margin can be reduced by better organisation of the rural community, is not transparent. Important as well, that Tree Oils stated not to be interested in contracts with farmers on less than 20 acres and not to be interested in farmer groupings. Here positive social effects, at least for small farmers, are at risk.

4.6.7. Financing

All projects discussed have given financial support or support in kind for the establishment of the crop, sometimes as well for liquidity to farmers during the first year without yield. However, no financing mechanism has been crystallized nor intense discussions been observed concerning financing mechanism for the present National Indian Program.
To replace a relevant share of diesel in India, massive investments are required. Government financial sources are mainly directed to State institutions that are meant to then channel these funds through their own existing financing schemes, or use the money directly for project expenses.
80 % of funds are earmarked for cultivation of Jatropha, about 20% for R&D for transport, storage, engine modifications and processing. In some cases, the State Governments contribute own additional funds. To deal with the high initial capital demand and long period for Jatropha cultivations, until they reach full maturity, Government may have to provide loans for growers directly as well. It will be necessary to analyze the current prospects, potentialities and constraints of the Jatropha approach for microfinance to rural poor, women, cooperatives and tribal communities, since demand for liquidity will be substantial, if the program is to succeed as well with its social component. To enable the poor to access credit for activities that generate income, inclusion of micro-finances into the program should be considered to be made obligatory.
In the absence of an operational market, a demand push may as well have to be taken by legislation or by guaranteed buy-back agreements with minimum prices for the harvesting period of the trees - said to be up to 50 years in principle, however the economic optimum will be shorter - backed by Government. Because of its multiple socio-economic and

environmental benefits, Government may as well allocate and transfer public lands on a long-term basis. In addition, Government should try at an early stage to qualify for funds from the Global Environmental Facility.
It is important; to discuss and develop a clear set of financial instruments for farmers and other parts of the industry including rural financial institutions to rely on, beyond present subsidized demonstration projects.

4.6.8. Water

Access and availability of clean water need attention as seriously as climatic and energy problems. Jatropha is considered an ideal crop for India, better than sugar cane based ethanol, particularly, since “it does not require much water” and the country is facing huge water scarcity for which there is no economic solution as of now. Its drought resistance is one of the key arguments to promote Jatropha. Since in India shortage and low water availability are one of the main factors of those unused lands identified for Jatropha plantations, water use and yield response to droughts are crucial to the success of the planned program. This in particular, since Jatropha not only competes for water with other food crops but sometimes also with drinking water if used instead for irrigation. The areas visited suffered from a severe annual lowering of the water table and depletion of aquifers. Astonishing however, that actual information on water demand and yield response to watering and its frequency seems to be almost non-existent, apart from very few purely empirical observations yet. No comparison on water yield response compared to other energy and oil crops was found discussed or assessed.
Energy crops, in particular perennials, often have a high water use due to their long growing season and deep rooting system. Therefore, aspects of Jatropha water use can be decisive for its sustained introduction for energy utilisation. There is a variation on water use of different crops for biomass production by a factor 50 according to genotype and environmental conditions, however information on Jatropha´s annual water use structure and respiration losses, its needs in different root zones a. o. seem to be not yet established. All what is known, is that Jatropha sheds all its leaves with severe water shortages.
There is a common understanding, however, that green cover to unused lands acts in favour of the overall water balance in respect of soil and microclimate, however effects of this perennial on aquifer and ground water recharge are not that obvious. Erosion control is undoubtedly a positive factor, plantations can be used for rainwater harvesting, and favour watershed management projects at hillocks. However, the comparative overall effect on aquifers seems to be not well known. One microclimatic strategy to reduce the saturation deficit of the air surrounding the crop is to introduce agro forestry systems, this can alter humidity, radiation and temperature for under storey crops; however, water use may increase as well and thus limit the agro forestry strategy in areas of limited water resources. If Jatropha itself turns into the under storey crop in reforestation programs with larger trees, then all reports found so far, state severe yield limiting effects up to zero fruits per tree.
Since there are reports, that droughts and water logging have destroyed young plantations, information that is more detailed needs to be collected on real behaviour at extreme conditions.
Assuming two irrigations per year, as assumed in the National Program is hard to go along with, since if irrigation systems are available, then higher frequency should be expected or recommended. This corresponds as well to the information gathered in India on commercial Jatropha use, where all discussion partners assumed that regular irrigation appears to be a precondition for any active and commercial plantation efforts in those areas. Tree Oils India did not even want to make any contracts with farmers that use rain fed lands.

The example with high and fast yields seen in Erode, did use daily irrigation from a waste water treatment plant at Indian Railways, one possible approach towards better yields, economies and cost for irrigation. The Nicaraguan and Belizean example, often cited in India as examples for assumed high yields, have mostly much higher rainfalls than the average precipitation in India. It appears therefore most crucial to clarify actual yield prospects on rain-fed areas in India, or discuss cost and effects of irrigation, to avoid further investment failures.

4.6.9. Botanical and Cultivation Issues

Jatropha is said to be a drought hardy shrub, non-demanding, tolerant to extremes, suitable to tropical and non-tropical climate and considerable climatic changes, even up to light frost. Tree borne oil seeds have always been a component of traditional agricultural systems practised in India. However, the degree of domestication in tree-borne oilseed species as a whole is at a very early stage compared to most cultivated crops. Increased domestication and increased inputs might increase pests and diseases, now assumed low in Jatropha. However, there are no chemical pesticides known to be applied, discussed or developed against any Jatropha pest so far. For fertilizer application, all parties prefer organic fertilizers. Influence of increased mineral fertilizer and water doses on pests, oil content or yield are not known. For mixed cropping, for under-storey crop rotation and as well in Forestry Programs, Pongomia might be particularly interesting due to its nitrogen fixing characteristics and its tall growth. In intensively cultivated areas, irrigated lands might be used for food production, recommending to direct breeding from maximum yields towards reduced input needs for those cases. For forestry projects, possibly as well for farm-based agro-forestry, the shade tolerance might be the key selection criterion to be further developed.

Male flowers dominate the plant; flower visitors needed for the predominant male flowers include bees, ants, thrips and flies. To what extent bees can be produced with positive synergies on Jatropha pollination and honey yields is an open issue.

Researchers from the University of Hohenheim are said to have found particularly resistant high-yield varieties in Mexico and Mali; these are being tested in India. As well, they have tested survival rates of samples from different regions of India with a wide variability. The University in cooperation with Daimler-Chrysler is planning some systematic research on yield patterns. One hope of improved economies for Jatropha has been for long non-toxic species. One non-toxic specie, without known yields, has been found in Central America.

Another hope is the cost efficient detoxification of the oil cake to use the cake as higher value feed for livestock, but reducing organic fertilizer availability.

There has been little genetic improvement, identification of elite germplasms, tissue culture experiments and propagation so far nor a systematic or coordinated capture of genetic resources in seed banks for its regeneration, hybrid production and sustainable cultivation.

As well, preference of cuttings, seedlings (with or without polybags), or other propagation methods, the level of pruning, trimming, to extend the juvenile phase of the plant, and suitable spacing of the plant has barely been optimised so far. Lifetime under cultivated conditions is not known yet. Plant density recommendations fluctuate between 1000 plants and 5000 plants per ha, with no relation to genotype, cultivation method or soils. As well, there are still a number of open issues to be researched on optimal flowering and fruiting patterns. Timing and degree of pinching, pruning and a close cut, as recommended by CDRC for the fifth year to 45 cm might want further refinement. For the micro credit schemes, factors influencing time lag until full yield can be achieved on different lands, is of paramount importance, however not yet known. Uses as pesticide, moluscicide and for medicinal purposes might as well require specific selection, breeding and cultivation practices.

4.6.10. Competing Resources

Jatropha is competing with other food and forest crops for land, water, nutrients, sun, labour, private and public capital and institutions. It is competing with investments in other non-edible and edible oils, with renewable and non-renewable energy sources with other programs to improve the environment, for employment, rural industrialisation and poverty alleviation. Different cultivation systems and program designs change the pattern of competition and relative advantages. A thorough economic analysis has to assess opportunity costs of these factors and their sensitivity.

On present markets and within reforestation and renewable energy programs the crop has barely been able to compete successfully so far. The Indian National Jatropha Program, as far as can be seen, is not yet based on an analysis of competing production factors. There exists some comparison between different crops to replace diesel, and there is a very broad base of field experience from different organisations and from energy and rural development specialists integrated into and influencing the Indian National Program.

In any case, a number of factors are changing in favour of Jatropha. There is indication that viability of Jatropha, if not attained yet, is a question of time. If this is the case, then broad preparation to be commenced now, is well justified. Changing factors are the following: Increased demand and costs for diesel, higher foreign exchange needs for diesel; an increase of non-cultivated, non-forested and eroded lands; higher rural energy demand and energy costs; and, at the same time, a decrease of rain and water availability, as well as decreasing rural incomes.

A main concern of the international discussion on bio energies is whether less food is available with increased Jatropha cultivation to the low-income population. In the Indian Government program, officially mainly non-used land is targeted for Jatropha and present price levels do not indicate that Jatropha can directly and successfully compete with agricultural crops and vegetables grown yet. In the contrary, it is argued that Jatropha paves the way for an increased food production in those fields that have not been used and "green covered" in the past. If the rural poor have to use a major part of their income for energy purchases, this will reduce their purchasing power for food and other needed items as well. If indeed lands are cultivated, which lay idle so far, employment generation would reach women and low-income groups in the villages.

Those who control their pieces of land for subsistence food production are far from replacing it by Jatropha. Those who do not own any land, get a better chance to find work. Additionally, Government plans to support an approach, which focuses self-help activities, social forestry, cooperatives and the like, to assist organizations of rural poor to improve their living conditions through increased Jatropha cultivation.

Whether it would be more advisable to cultivate other crops cannot be judged on an abstract level; it is assumed and hoped that growers themselves will make a rational investment decision, if conditions and guarantees given are favourable. Here policy has to avoid a negative change and fluctuations in prices and markets, since Jatropha is a long-term investment and can ruin a farmer, if minimum revenue cannot be maintained.

Competition for land might be more of an issue, since many of the non-used areas, are mainly not used by their owners, but might have low intensity use by some landless, tribal populations and others. However, during discussions it was emphasized that this would only be a minor issue, since most of the lands in question have already clear-cut rules and use or non-use patterns. If irrigation and fertilization is considered necessary and installed, then obviously other crops could be established in those lands as well and possibly increase benefits.

Of course competition with labour, even though abundant in many villages and capital will occur. Nevertheless, here too market forces on the base of each program will select the preferable option.
Therefore, concern with regards to an increase in poverty is justified mainly if the program is not well maintained and designed, turning investment into lost capital and thus reducing rural income. As well if the programme uses public funds for larger plantations, institutions and well-off farmers only, this results in an increase of welfare disparity, contrary to intentions.

Compared to other bio energy efforts the nearest comparison goes with the alcohol program from sugar cane molasses meant to replace 5% of the national petrol consumption. Sugar cane fields are normally prime land, often asking for severe fertilization and irrigation, being grown as a monoculture and not known to improve soil quality. As well, sugar cane, to a lesser extent in India, is often grown on large plantations, which would be well suitable for food cultivation of low-income groups. Hence, from a social and environmental point of view, Jatropha seems to be more recommendable. Besides this, there is Pongomia, a large tree grown disparate and needing longer to mature. With a longer record of accomplishment in Southern India, the oil is however technically a little less suitable as a diesel substitute. Other edible, and some non-edible oils too, have, due to their human consumption and often-industrial uses, considerably higher prices and - for this reason alone - can barely be used as a diesel substitute. Since a broad range of oil processing industry operates already in the country, an additional supply of Jatropha might help to use existing capacities of those industries and strengthen further development of processing companies.

In summary, the Jatropha program is felt to compete not directly with food production, however, economic mechanisms are complex to preview the full chain of effects. Positive effects on poverty alleviation are thought to be clearly dominating if compared to many other energy projects. An optimisation, however, asks for an analysis that is more detailed.

4.6.11. Nutrient Aspects

The efficient use of nutrients in the production of Jatropha is important to minimise the input needs. Efficiency of nutrient use of Jatropha and best respective cultivation practices, have not yet been found discussed. The high wooden content indicates a high efficiency of nutrient use. However, high nutrient levels of fruits removed indicate rather a high nutrient removal, which need to be returned to the soil. In particular, nitrogen needs to be considered, since Jatropha is not a legumnosae. Perennial crops are usually efficient at taking up Nitrogen due to the long growing season and the permanent and deep root system. The absence of tillage in an established perennial Jatropha crop will furthermore reduce mineralization. Consequently leaching should be limited, apart from during the establishment period. In Nicaragua however mechanical tillage was performed in most fields. The permanent cover can reduce surface run-off of soil, nutrients and organic matter.

Predominant sale of the whole seed, the storage organs, to the oil mill, which then sells on the material in the local market as a fertiliser for higher value crops (at 3-5 Rs. per kg), has to be considered critically in respect of long-term yields of Jatropha. Assessments in relation to the actual fertilisation protein rich effects of Jatropha cake were not found in India. A more thorough analysis on who is buying the cake for what purpose, crop and means of application should be made to get a better picture about market potentials and whether the cake has a chance to be returned to Jatropha fields. In any case, nutrient and fertiliser needs and best frequency of application for Jatropha in relation to its yield pattern appears to be still largely unknown.

CDRC, a successful nursery in Erode, recommends ½-1 kg of farmyard manure plus 100 g of Neem waste for every seedling, with a recommendation of 5000 plants per ha this comes up to 5 t organic fertilizer per ha. For Jatropha fields they recommend 2 annual fertiliser application with 150 kg Superphosphate being the first dose, to be increased by 10% every year and 180 kg NPK the second.

For the use of the cake for biogas conversion, no practical example has been found, nor any yield figure concerning gas or energy output expected. In any case, anaerobic conversion would leave the fertiliser value untouched and increase local on-site energy supply.

Comparative studies with other non-edible and edible oils would be desirable as well. For commercial production purposes, farms and nurseries all assumed a regular fertilisation demand, preferably through organic matter. Without fertilization, yields will barely build up to discussed levels according to soil type and other factors. Quantities needed, composition and frequency want to be assessed in detail. Here as well, the use of waste water, sludge or even solid wastes to improve nutrient balance and viability, should be looked into more seriously.

4.6.12. Forestry Issues

According to a 1999 FAO report, India is the only developing country with an increasing forest cover, in 2001 the increase was reported to be 2000 km2 to beyond 20% (with 0.08 ha/capita) of overall area, up from 19% but below a 33% target. Even though there are many measuring problems including the increase of commercial forest, difference between dense and open forest, different assessment techniques a. o., there is serious effort ongoing in many Indian states towards rehabilitating some of the degraded forests. Successes are largely attributed to Joint Forestry Management Program (JFM) approaches of the Ministry of

Environment and Forests, putting villagers as subjects and key players into the centre of reforestation.

At the same time, pressure on forests by wood trade and high incidence of demographic and cattle pressure continue to result in degradation of many forests with all its negative environmental, economic and social consequences. Neighbouring villagers have to meet their energy, small timber and grazing needs. Several million villagers are estimated to enter the forests on a daily basis to meet their requirement in one way or other. Removal of firewood as head load from forests is a common practice not only to meet homely needs but also as a means of livelihood. Unproductive herds of cattle are raised in forests to provide manure or to be used as draught animals and allowed often for unrestricted grazing. Villagers often depend on forests to meet their green manure requirement and sometimes intentionally set fire to encourage fresh growth of grass. Forests are catchments for many rivers and water supply systems. Another reason for encroachment is illegal logging. In India people’s participation and empowerment, turning forests into common property resource of villages and JFM´s, must play the major role to guard against further forest destruction. Social and Community Forestry Committees have apparently been a quite successful means of “care and share”, with strong positive response by villagers. Increasingly wildlife protection is approached with the same strategy. New guidelines stress that JFM Committees should be treated as the 'Basic Forest Management Units" and given authority to act, as well as supplied with adequate incentives to participate as genuine stakeholders. To what extent JFM´s are successful as well to promote agro-forestry and resulting synergies, with trees traditionally not always appreciated on private farmlands, is not obvious.

Forestry plan of action for Jatropha should be based on these experiences and should become a holistic one, including synergies between village common and private lands. The non-political identity of the JFM Committees as 'guardian of forests' should be mobilized for Jatropha including capacity-building effort. JFM´s are meant to account for up to 50% of the Indian Jatropha Programs efforts, respectively 200.000 ha immediately, 6.5 Mio ha at a later stage, and could possibly contribute to a better knowledge and understanding of all parties on agro-forestry and its productive and protective potentials and limitations.

Past discouraging experience with Jatropha in forestry programs has shown that fruit yields, often due to competition for light, tend to be rather close to nil, at least in densely planted forest areas. How much better spacing and mixing with other trees can help, is not known. With buy-back agreements for the seeds and oil as planned, people’s interest in Jatropha might increase to plant gaps and patches in degraded forests with Jatropha. However, how to technically integrate Jatropha into forests in a productive and sustainable way, how to organize property issues and whether Jatropha can compete with villagers’ income from wood sales from other species in present community forestry programs has not been analysed and documented so far. The wood is considered hard or semi-hard, however, crippled growth make a commercial, non-energetic use, besides for fencing difficult. To use a successful communal village approach for a management system, where results in terms of yields are questionable, would serve none of the actors. Here again, a more thorough discussion on inter-sectorial linkages, data assessment and careful testing including an improvement phase is needed to avoid additional setbacks, that might be hard to correct after planting has started.

4.6.13. Environmental effects

A similar argument applies for environmental effects mentioned on a regular basis.
In line with the lack of economic effects, all environmental effects on soil and water will dissolve latest after uprooting of the plants. Where efforts are part of a reforestation effort,

there will be always positive environmental effects, once the plants are allowed to persist. Comparative to other species, there is no indication that effects are more positive, since biomass growth is not rapid and dissemination through the Joint Forestry Programs was so far rather discontinued. There is some result reported in watershed management, even though not yet in terms of crop yield and only related to persistence of plants. There are no reports on bee production and bird protection available yet.

Bio-diesel is ecologically benign since no carbon dioxide is emitted into the atmosphere and secondly, it sequesters carbon from the atmosphere through photosynthesis from plant growth. India has signed the Kyoto Protocol and with bio-fuel being an instrument of clean development mechanism, India can profitably trade carbon saving with developed countries through accruals of carbon credits apart from not emitting carbon into the atmosphere on its own. The Jatropha energy, used so far mainly for demonstration purposes, has the potential to offset environmentally and climatically harmful emissions from diesel. A lifecycle analysis claims a reduction of CO2 to be 2/3 of present CO2 emissions from petro-diesel. Other figures (Prof. Becker, Hohenheim) assume a 10 t reduction per ha (10 times per capita emissions of presently 1t/a/person in India, 10 in Germany, 20 in the US), which could, according to future reduction cost, become a valuable addition to the economy of the system. There is some risk that a rise of CO2 prices might still have to wait for a few years to come, considering present Kyoto ratification status, emission trading and international policy focus, unless major climatic catastrophes and its costs (presently said to be close to 60 billions/a, and rising) change attitudes rapidly. However, even from US-Pentagon there has slipped a study just recently, stating that "significant global warming during the 21st century and resulting conflicts"... "would challenge US national security in ways that should be considered immediately". However, a major change in green house gas pricing or international assistance focus towards green house gas abatement to include bio-energies should not be expected from this in the short term.

In addition, other emissions, like sulphur (up to 100%), particulate matter-dust (30%), Carbonmonoxide (50%), Hydrocarbons (90%) and others from diesel combustion are reduced considerably through actual bio-diesel use, improving living standards and contributing to lower health care costs.

Extent of environmental effects up to now has been negligible in quantitative terms, but effects of the now planned program can become respectable, if to succeed. Field studies to allow assessment of a number of different effects and a quantitative evaluation of environmental and climatic results should be prepared.

So far no information on the impact on biodiversity in forests, farmland or waste land has been found documented.

4.6.14. Economy

Viability of Jatropha cultivation is different depending on region, farmer, purpose, season and other factors. As well, it is not easy to agree on the value of non-monetary factors, and who gets the benefit and has to bear the cost. Mostly farmers and agro industries will have to focus direct monetary returns on their investment to repay loans and secure a living. A key problem to the present approach in favour of Jatropha and its success prospects is the way, how benefits are being calculated, and the level of detail that is attached to these calculations. There is quite some risk that overoptimistic assumptions once again will jeopardize the effort and its long-term success.

Economic effects from past Jatropha programs are not noticeable yet; in the contrary output in terms of plants, left to grow and produce to use has been considerably below expectations. Commercial Jatropha cultivation has not been viable so far, uprooting of several thousand acres Jatropha by farmers rather indicates that income and non-monetary effects have been below costs or at least below opportunity costs. Nonetheless, a few small markets found, indicate that there is a sustainable way to cultivate Jatropha in India without subsidy. The minimum wage being at par with 2 l of diesel supports this notion. These existing markets ask for further study. It is assumed however, that investment cost for planting and land cost are barely part of the seed price here, which rather reflects the collection, intermediaries and harvesting cost from life fences and watershed plantations. As well, there is now developing a virtual market coming up even in the Internet, which cannot be satisfied from present production rates based on demand of institutions and people, who want or have to work on Jatropha due to recent Government policy.

Macroeconomic benefits from energy crops like Jatropha are expected to become substantial in the medium term for countries like India, and this is motivating a joint effort for further promotion of this crop. The optimism results from all the known factors like greening and regeneration of underutilized land including a better water balance, income to the poor, energy to the poor, climatic effects through CO2 digestion by Jatropha trees, reduced CO2 emissions from fossil fuels; as well from air quality and health effects through reduced toxic emissions and a reduced foreign exchange bill.

Even though not to be argued about, few of these effects could be monetarized or quantified on a theoretical level, even less on an empirical level at any sizeable extent up to date. Only sustainable growth and use of Jatropha will allow these effects to materialize and be measured; and only with relevant crop and monetary yields, Jatropha will be planted on a sustainable basis.

A field project with heavy subsidy, as planned by the Indian Government, to collect more data, and prepare for the future, is therefore most welcome. Nonetheless, most non-monetary or macroeconomic, common effects do not reach the producer, they have to be transformed into rural cash income to JFMC´s, farmers, labourers, industries credit institutions, who are meant to be the ones to disseminate the technology on a sustainable basis in the future.

This political transfer to Jatropha growers and processors is a precondition for future production and it can only be well designed and justified based on thorough and trustworthy economic analysis, thorough yield figures, and presumably, considerable yield improvements. Effects only materialize, if a sustained dissemination program is put on the ground, and succeed, if yields reach an acceptable level for stakeholders, in particular farmers and private investors.

As in all known programs of the past it is felt that figures on yields and costs are sweetened and thus do not allow investors a rational investment decision for Jatropha based on market forces. If Government wants to support and create the market in the initial phases in a transparent way, it is crucial to have correct figures on hand along the whole production chain.

Cost factors feared or felt to be possibly underestimated are:

- costs of fruit and seed
- cost of middlemen
- wholesaler
- transport
- processing
- handling
- storage
- training
- overheads for management and administration

water demand
fertilizer demand
quality of soils
tillage needs
plant care
light demand
time and
adaptation of engines

Yield factors feared or felt to be possibly overestimated are:
survival rate of trees,
homogeneity of seedlings
drought resistance, resistance against water logging
disease resistance
fruit yield
seed yield
dry seed yield
oil share
oil yield
fertilizer yield
glycerol yield
availability of processing technologies
pharmaceutical value of plants
availability of land
other effects including poverty alleviation will only come true, if projects are designed with a particular emphasis to this effect.

At the same time, the following factors might compensate for some of the above:
Rise of productivity along the production chain
Increased energy demand and cost
Other rural energy and non-energy uses of Jatropha
Monetarization of greenhouse gas balance
Increased demand for an improvement of soils and lands
Increasing economic instruments to support green production to protect soils, water and micro climate
Increased need for poverty alleviation and rural incomes
Potential of intercropping and other synergies
Interest of international cooperation in large scale successful projects in this field

Risks for the above uncertainties can and should not be shouldered by small farmers, but be considered part of a political decision, as targeted in the Indian national program.

New technologies and their applications sometimes require long preparation periods, mostly much longer than presumed, since data have to be generated and numerous technical and non-technical barriers have to be tested and overcome. This has to be pointed out more clearly and realistically to focus key productivity and viability questions and issues of financial liquidity, and to address uncertainties through climate a. o. in a more coordinated and focused manner. External costs on fossil fuels, electricity and CO2 reductions should be compensated with a fixed bonus towards Jatropha in the framework of guaranteed purchasing agreements. There is no need in the preliminary phases of this approach to come to par - as proclaimed - with present diesel prices, which themselves rather deserve to be considered subsidized in a number of ways.

Of course, if legislation is ultimatively requesting (and controlling) oil companies and public institutions to blend all diesel with 5% Jatropha diesel, then the market price would be sufficiently rising. However, since farmers will only invest into Jatropha based on fixed price guarantees, it will be crucial to design contracts now in a way that allows them to participate at rising Jatropha fruit prices. Otherwise, yield expectations raised by sensitisation programs and rural officers would have farmers to be the ones again left with disappointing returns on investment into land, labour and opportunity income. The same might apply for oil mills and bio diesel producers, if they start new investments. Results from a study made in Tumkur district, based on fruit collection only, showed higher costs for fruits and oil averaging 7.50 Rupees for seeds and almost 30 Rupees for oil. This might indicate that expected seed prices of Rs. 5 (0.1$/Euro) and bio diesel prices of Rs. 17 are too low. An average of 1.2 tof oil expected from rain fed degraded or forestry land with only 2 irrigations seems, based on existing experiences in India, barely practical. Prof. Becker from University of Hohenheim has calculated economic returns based on more conservative returns (1.5t seed/ha on low nutrients waste land), even though for Madagascar, and gets a net present value of 730 $/Euro and a IRR of 20 years based on 10% interest and a low leasing rate for land. However, here a 40% income from inter-cropping still had to be included on the benefit side.

4.6.15. Energy Issues

In Delhi it is forbidden to drive a diesel-powered vehicle, in view of the resulting high levels of air pollution. Government puts increasing emphasis in India to reduce urban pollution. The Indian government is therefore also interested in finding a clean fuel that can be produced domestically, in order to alleviate those environmental problems.

Biomass energy sources in India have for long been thought to be old fashioned and environmentally destructive. There is a major shift in policy conception that perceives biomass energies to be convertible into modern energy. This not only applies for bio-diesel and ethanol, but even a growing percentage of fuel wood is increasingly produced in non-forested areas and used efficiently for energy purposes.

Biomass energy can help in soil and water conservation, restore fertility and increase agricultural productivity. The Government program in India not only focuses on a centralised approach of bio-diesel use, but a decentralised use as well. Government wants to promote and develop decentralised combustion and conversion equipment like pumps, stand-alone oil engines, furnaces, lamps, kilns, burners, stoves. There are a number of applications for Jatropha oil without esterification, in sturdy diesel engines and pumps, for light and to a lesser degree for cooking. Mr. diesel himself originally developed diesel engines for use with vegetable oils. Therefore, if the market for bio-diesel does not develop as expected, then these uses might still be a buffer for Jatropha producers. Other energy uses of the wooden parts of Jatropha, stem, branches, husk and shell receive only minor attention, but should be included into the overall energy balance and discussion.

Electricity boards, that supply electricity through the grid incur huge costs in drawing lines to remote areas and unto the irrigation well-points, which results in high distribution losses as well, often not getting paid by farmers. Subsidies on electricity and kerosene in rural areas are reduced stepwise to different degrees in different states. Here as well, a future market is upcoming, as long as bio-diesel production is not fully established.

4.6.16. Prospects of Diesel Price

Discussing the future diesel price is highly speculative. However, seeing that Jatropha in present conditions seems to be difficult to grow on market-based conditions, the diesel price might turn out to be one key factor besides upgrading of land, income and climatic improvements for a medium term national policy justification of Jatropha and other bio-diesel activities, even based on real production costs.

The world crude oil is becoming more expensive. International petrol oil companies state to produce at the limits of those capacities, which can be used, already squeezing present reserves to the limits. From overall capacities (about 1000 Gigabarrel) about 30% can be used, beyond this mostly there is more energy needed for exploration than the energy content of the crude. Reserves have been overestimated for long and a further surge of the petrol price due to growing demand, higher exploration costs and reduced reserves in the next few years appears almost inevitable. Oil companies see the peek of production and consumption of crude with 30 Billion barrel in the year 2010, for gas with 45 Billion Barrel oil equivalent about eight years later. The share of the Middle East crude is then expected to have risen from 28% now to around 37% in 2010 and 61% in 2050.

Present estimates of reserves from international companies have been constantly down graded, coupled with low recent investments in new capacities, due to rising exploration costs. This is one reason for low share prices. Shell being the most prominent example that downgraded their reserves three times this year, their quiet reserves used in the past for prospect announcements have been used up. In Oman production has gone down by 70%; the biggest oil field in the world of Saudi Arabia (Ghawar) is already being squeezed out to the limits by adding water, indicating that even the largest producer and country with the largest reserves (followed by Iraq !) has reached its peak. Vice president of Exxon Mobil already declared in 2002 that production and demand are not balanced any more and that additional investments until 2010 of around 1000 Billion $ are needed, which none of the international companies has on hand.

However, since 1980 there have been limited investments, with capacities of refineries, pipelines and even ships fully being used. Shell, Exxon, Chevron and BP all declare that their production will decrease in 2004, due to oilfields used having passed their peak. New fields ask for much higher investments and thus increased oil prices. The fields in Alaska and the North Sea, which buffered the oil crisis of the seventies are becoming exhausted (annual production decrease of 10-15%) and had reached their maximum in the year 2000. New fields like in Mexico and Brazil and some African countries in the sea are extremely deep and thus considerably more expensive to be explored, environmental effects not considered. Even gas price, due to lower production than consumption in the United States have doubled in a short period. Reserves in India are thought to last another 20 years at present import rates (around 70%). From production cost by far the cheapest petrol oil is presently still found in Iraq.

From the rapidly increasing demand of oil from China alone immediate price expectations for the next few years are more likely to be > 40 $ than at $ 25 as targeted by OPEC or at > 30$ as in the last few months. Not included are present economic growth rates in India (8%) and its impact on international crude oil demand and pricing. The argument does not include further conflicts in the Middle East and other petroleum conflicts neither.

While other renewable energies for electricity production are very slowly forthcoming, options outside bio-energy as the main transport energy alternatives and for rural energy demand are limited. Alcohol from sugar cane, which is to substitute 5% of diesel through

Ethanol in the next five years, is already using scarce fertile lands, which, due to the land tenure structure, often serves fewer people, needs watering and could easily be used as well for food production. Efforts to produce a standard synthetic fuel from any type of biomass (Sun-fuel), as supported by large carmakers in Germany, needs huge investments, further developments and might be competing with other biomass uses as well.

For India, without a realistic perspective to cover crude demand from own sources, it is mandatory to publicly invest into an alternative development concept, which at its minimum takes 5 - 10 years to mature even into a low share national substitute of diesel. And to not allow a growing >50 Mio ha of land to lie idle and increase shortages of food and resulting environmental problems, asks for even higher investment.

For the Jatropha program to be supported by the public even at true costs, a strict and independent monitoring and control scheme to control public funds and spending is needed. The objective should be to create a base and sustainable mechanism for a bio energy and bio diesel production, with environmental and social goals, as outlined in the National Program. A good management of funds will thus be more important in case Jatropha and bio-diesel prices go beyond or even reach twice the present diesel price. Advanced models to calculate micro and macroeconomic viability, including environmental, social and future effects, need to be agreed upon and applied.

The biggest mistake would be to get farmers to invest into Jatropha production, while opportunity yields and income are higher. Lasting disappointment, mistrust and uprooting of crops would be the result, which cannot be easily compensated. If a 5% share of bio-diesel added to all diesel vehicles is to be reached within the next 5-year plan, investments might have to become even more substantial in the years to come.

Each additional $ of oil price, surges import costs of the Indian economy about 500 Million $ at present import levels. The presently planned program by the Indian Government of 300 Mio $ for 5 years represents thus the equivalent investment of 12 US cents per barrel imported crude or less than 4 Paisas per litre diesel. This could be a good start, but possibly not good enough in terms of a Indian forward strategy, considering the future prospect of crude import cost, scarcity and resulting economic, environmental and social effects.

4.6.17. Data Base

Very few documents analysing experience with Jatropha and no figure or estimates on present Jatropha plants in the country, whether wild or cultivated, were found. This includes the National task force report. Accordingly, present efforts are not noticeably based on documented lessons learnt or systematic evaluation of these efforts. It is assumed that considerably more reports are existing somewhere in India, however since they are difficult to find, their use is limited. Interviews with farmers, village heads, women or elderly living from and with Jatropha reporting their actual field experience were almost not found. Data and studies refer considerably to each other, creating a dynamic, which can be positive if this means exchange of experience, but negative if wrong figures are being repeated. For example, the Indian national activities include a lot of references to the experiences, perceived as positive, made in Nicaragua and Belize. As well fruits, seeds, and kernels and referent ha and oil yields are not clearly named in documents, being the cause for some of the immense variations (the kernel represents only 40-45% of the fruit) in expectations and confusion on actual yields. It is felt as well, that those officials responsible for program designs and report writing in India might have had limited time to visit farmers and collect empirical information. Found figures about uprooted plants and plantations in India are higher than figures on planted fields, actual existing plants or about existing or harvested acreage found. Documents on actual or past environmental, social or economic improvements for the target groups do not allow concluding that any of these benefits dominate or are widespread. There are fascinating potentials of the Jatropha plant reported, but positive conclusion on the actual use of these potentials are not permitted. Increased field observations, reports and data collection will have and are meant to be part of the planned national program.

5. Conclusisons/Recommendations

Jatropha is a valuable multi-purpose crop to alleviate soil degradation, desertification and deforestation, which can be used for bio-energy to replace petro-diesel, for soap production and climatic protection, and hence deserves specific attention

Jatropha can help to increase rural incomes, self-sustainability and alleviate poverty for women, elderly, children and men, tribal communities, small farmers. It can as well help to increase income from plantations and agro-industries.

With past Jatropha programs experience, sensitization and knowledge have been increased internationally. However, success and relevance in terms of acreage, poverty alleviation, environmental impact or energy production has been very limited.

In none of the projects looked into, the development potential of this crop has been translated into sustainable rural development; actual impacts did not meet the predicted ones; actual results have only sparsely been documented

Site specific yields tend to be overestimated, necessary production factors and economies have not been sufficiently considered, a suitable political and institutional framework was not in place yet

The still rather “wild” plant only produces expected fruit yields if adequate plant material is selected, bred and multiplied and if minimum cultivation standards (pruning) and production factors (water, nutrients, light) are being met.

The multipurpose benefits, their interdependency and preconditions are barely anywhere integrated and used in practice. Yield predictions need to be more realistically correlated with water, nutrient and management demands.

There is no indication that Jatropha promotion needs to reduce food availability for any social group in India; it is rather expected that successful promotion of Jatropha and similar crops can assist to improve sustainable income, food and energy supply in rural areas

Information available on activities in Nicaragua indicates that there have been no sustainable beneficial results for income or environment, rather the contrary. The project has raised almost any expectation beyond realistic targets. Another key shortcoming was a lack of social and economic understanding of the producers of the Jatropha fruits and seeds.

For the project in Belize, no documented effects beyond reforestation could be identified. Fruits are either not produced or not used. Information about comparative advantages and disadvantages for reforestation with Jatropha alone or in combination with other crops is barely available.

Indian efforts of the past have not met targets due to a number of factors including limited financial means (of what?) and inadequate framework conditions. Even though much closer to sustainability for a broad range of reasons than in other countries, the necessary critical mass for sustained use had not been attained in the past.

The present effort of the Indian Government is by far internationally the largest and due to its integrated approach most promising so far. The main risk is an overestimation and uncritical addition of different potential yields regardless of the inputs needed

For Jatropha, low inputs and high yield do not yet go together. The present program argument, even though touching many important issues, still indicates that quite some of the illusions and mistakes made in earlier programs in Nicaragua, Belize and India are to be repeated once again

The ambitious program, that focuses most key development issues in India asks for additional support by the international community, as well to allow learning from these experiences for other countries

National and international efforts should be more concentrated and coordinated as follows:

- Focus Jatropha activities on India in support of the National Council coordinating the project to help to make this unique “National Mission” a success
- Analyse in more detail and productively use shortcomings in Jatropha and similar approaches in India and other countries
- Determine a realistic relation between inputs and yields in different climatic, environmental and social settings through multifactor trials
- Improve productivity through selection and breeding of plant material, improvement of cultivation techniques, processing and marketing knowledge;

Specify social, environmental, financial and energy targets separately and assist to use specific instruments for each and for their integration;

Improve financial and economic data collection and comparative analysis to avoid additional failures and future major uprooting of crops through unsatisfied farmers

Collect comparative data for other crops eligible for similar projects or mixed plantations

Assist to integrate this program productively with other efforts for self-help, community development, women empowerment, tribal organisation and into existing programs against poverty, soil, forest, water and climatic degradation

Improve know-how exchange, institutional networking and support nodal agencies to secure up-to-date know-how and advanced learning from mistakes on specific issues of the past, present and future

Get an independent, transparent and reliable control and accounting system in place to avoid irregularities

Based on the above, identify a regulatory framework that secures a stable demand - for example through a realistic, reliable, mandatory and gradually increasing share of bio-diesel to be blended with non-edible oils produced in India - and thus secure prices for the whole production chain.