Use of the Physic Nut (Jatropha curcas L.) to Combat Desertification and Reduce Poverty

Possibilities and limitations of technical solutions in a particular socio-economic environment, the case of Cape Verde
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1 BACKGROUND AND APPROACH

As one of the 186 countries to sign the International Convention to Combat Desertification (UNCCD), Germany made a commitment to support the process of implementing the Convention in developing countries. The Convention Project to Combat Desertification (CCD Project) of the Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, situated in Bonn since 1999, is carrying out this task on behalf of the Federal Ministry for Economic Cooperation and Development (BMZ).

The most important activities of the CCD Project are effective mainstreaming – linking the CCD process with other important elements of socio-economic development and with development strategies (e.g. poverty reduction, water management, conflict prevention, decentralization, etc.) – and support, improvement, and further development of CCD implementation at the regional, national, and local levels.

For advisory services and further development of measures to counteract desertification, technical solutions also play an important role, particularly for local initiatives to combat desertification. Bilateral development cooperation, for which combating desertification has been a priority area of promotion since the mid-1980s, has gained worldwide experience in this area.

The objective of this study is to present the possibilities and limitations of technical solutions to combat desertification and reduce poverty in a particular socio-economic environment.

This case study concerns the use of the physic nut on the Cape Verde Islands. Especially in the 1980s and 1990s, GTZ projects in Africa gained a great deal of experience with the Jatropha plant. There was, for example, also a rural development project with physic nut components in Cape Verde.

In the following, the potential and the problems of using the physic nut specifically in Cape Verde are presented in the form of an evaluation of available information from GTZ projects and information about the social, economic, and environmental effects of promoting the use of the physic nut to combat desertification and reduce poverty.
2 THE PHYSIC NUT: INCIDENCE, ECOLOGY, AND YIELD

The physic nut tree or bush\(^1\) (*Jatropha curcas L.*), with a maximum height of five meters, originated in Central America and is today found throughout the world in the tropics. It belongs to the family of Euphorbiaceae and is very undemanding in terms of climate and soil.

As a succulent plant, the physic nut is drought resistant; it requires between 500 and 600 mm of rainfall. However, the minimum is highly dependent on local conditions. Thus, the physic nut also thrives on about 250 mm of rainfall per year in Cape Verde thanks to the high humidity. In times of drought, the plant sheds most of its leaves in order to reduce water loss. In addition, the plant can also be cultivated where there is a great deal of precipitation. It is very partial to warm weather and tolerates only light frost. The plant is extremely sensitive to wind; therefore areas protected from the wind should be chosen for single plants or strip plantings. The physic nut also thrives in the poorest rocky soils. Because of its extraordinary resistance to drought, it is suitable for stabilizing dunes.

*Jatropha* produces plum-size fruit with two or three oleiferous seeds. The seed and oil yields vary greatly according to origin and production conditions (climate, soil, plant spacing, water supply, fertilizer). Dry conditions, in particular, increase the oil content of the seeds. In Cape Verde, per-hectare yields of between 780 and 2,250 kg of seeds are harvested (MÜNCH & KIEFER 1986). In India, yields of up to 12 tons of unhulled seeds per hectare were achieved with irrigation, starting in the sixth year; in Mali, the yield was around 2 – 2.4 t/ha. Above all in regions with sufficiently high levels of yearly precipitation (900 to 1,200 mm), cultivation could be economically interesting, irrespective of external effects (e.g. protection against erosion) (BUNDESTAG 2002).

The seeds are toxic because they

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\(^1\) Names of the *Jatropha* species: physic nut, purging nut (English); pourghère, pignon d’Inde (French); Purgier-nuss, Brechnuss (German); purgueira (Portuguese)
contain curcin (a toxic protein) and phorbol esters. Pure curcin is highly toxic. Therefore, seeds, oil, and press cake are unsuitable for human or animal consumption. Because of the toxic and bitter substances, the plants are not eaten by animals. Furthermore, the physic nut does not compete with other useful plants. The physic nut is in general highly resistant to pests. Cultivation is possible through both generative (seeds) and vegetative (cuttings) propagation. Because of its resistance to browsing, the cultivation suffers few losses to animal feeding.

3 USE OF THE PHYSIC NUT

In the first half of the 20th century, the export of physic nuts comprised a large share of total exports from Cape Verde. Today, the Jatropha plant is not economically significant in any country, but is used locally for numerous purposes:

- **Soil stabilization in marginal locations**: drought resistant and few demands on its environment
- **Enclosure of fields**: in Africa the physic nut is planted chiefly as a hedge around gardens and fields
- **Traditional human and animal medicine**: seeds, leaves, oil: wound disinfectant, purgative, rheumatism, skin diseases, etc.
- **Biological pesticide**: insecticide and molluscicide effect (toxic for insects and molluscs)
- **Soap production**: from the oil of the seeds
- **Fertilizer**: the press cake can be used as high-nitrogen fertilizer
- **Energetic use of the physic nut**: curcas oil (oil of the physic nut) as fuel (motor, lamp, and cooker oil); entire plants and especially the fruit as biogenic solid fuel; curcas oil as lubricating oil for motors

Use of the wood is limited, because Jatropha provides poor quality fire wood. Because it is very soft, it is used as weaving material. The possibility of using the press cake of the physic nut for animal feed was investigated and proved inadvisable (see BOHME 1988).
4  THE CAPE VERDE ISLANDS AND THE PHYSIC NUT

Although the physic nut is found throughout the world, it has achieved notable economic importance only in the Cape Verde Islands, particularly on the Sotavento Islands of Fogo, Brava und Santiago. Here large groves were planted for seed production in locations where, given the extreme climatic and soil conditions, the cultivation of other crops was not feasible.

In the first half of the 19th century, the physic nut was an important export product of the islands. The oleiferous seeds were exported to Lisbon and Marseille for oil extraction and soap production.

After the demand for physic nut seeds continually declined due to the increasing number of substitutes for curcas oil and exports almost completely stopped after the independence of Cape Verde in 1975, the physic nut groves were used above all for firewood production.

As the result of an extreme drought during the 1980s, the physic nut became somewhat more important again in the framework of new measures to prevent erosion (agro-forest and forest-grazing utilization systems). In 1989, 5.4% of reforestation was done with physic nut. With the exception of the arid regions on the island of Fogo, there are no remaining large, continuous plantations because physic nut groves are no longer tended given their limited economic attractiveness. In addition, the chronic shortage of firewood on the islands has turned the plant into a source of firewood for households.

In general, the arid and semi-arid regions of the island, where classic rain-fed farming produces only modest or no yields, are very well suited for drought-resistant permanent crops. The cultivation and processing of the physic nut, whether as fuel or soap, meets the specific regional development needs of Cape Verde (suitable local conditions, no competition with the cultivation of food plants, need for jobs and income-generating measures, etc.).

(GTZ/RUDECO 1987; BÖHMEN 1988; HELLER 1996)

Production and productive life in the Cape Verde Islands:

- Nut production begins in the 4th year
- Peak reached in the 10th year
- No loss of productivity in the 25th year
- Recommended replacement point: 20th year
- Main harvest period in November / December. In addition, smaller amounts can be harvested almost all year.
- Production volume on the island of Fogo in 1981: around 600 t. Estimated yield at that time from a combination of spontaneous and systematic planting, and pruning: an increase in production to around 1,300 t in 10 years. However, according to recent surveys this potential yield is no longer accurate and is estimated at only 500 t. The production potential of the other islands is negligible because the groves were largely cut down or completely cleared.

(COSSEL et al. 1982; BÖHMEN 1988)
5 ASSESSMENT OF UTILIZATION AND MINIMUM LOCAL CONDITIONS

5.1 Protection against erosion and combating desertification

The undemanding plant is extremely drought resistant. Because of its few demands on the environment, the physic nut is used primarily to stabilize the soil in marginal sites. The dense, wide-ranging root structure protects the soil against erosion (above all from being washed away by rain) and serves as a nutrient pump.

A disadvantage of its use as erosion protection, however, is the lack of foliage in the dry season when wind erosion is greatest. The leaves are often not yet sufficiently developed by the first rainfall, so that there is also no protection against splash effects and wash-out.

The disadvantages can only be ameliorated through ground-covering, drought-resistant undergrowth. Mixed cultivation is possible, e.g. agave or drought-resistant forage, since in general the physic nut has no negative effects on other kinds of plants.

Existing feasibility appraisals usually did not take into account the reclamation of arid regions, protection against erosion, and soil improvement.

5.2 Living fences: enclosing fields

Even in times of food shortage, goats and other animals do not browse the physic nut because of its bitter and toxic substances. In Africa, therefore, the physic nut has proven useful chiefly as a hedge to enclose fields and gardens. In addition, the fences are easy to plant through vegetative propagation (cuttings). The enclosure of fields can contribute to a reduction of conflicts between herders and farmers.

Herders often tie their goats to physic nut bushes (Cape Verde) (MÜNZCH & KIEFER 1989).
5.3 **Traditional human and animal medicine**

Jatropha has been documented as a traditional medicinal plant in many countries, and the effectiveness of the resulting remedies has been, in part, scientifically demonstrated. The purgative effect of the seed is the most important. In addition, seeds, leaves, and curcas oil are used as wound disinfectant and as a treatment for rheumatism, skin diseases, and other ailments.

5.4 **Biological pesticide**

Because of its insecticide and molluscicide effect, the oil can be used as a natural crop pesticide. The oil extracts with toxic effects protect useful plants from various pests. However, it is not easy to handle these oil extracts. A too strong concentration is in turn harmful to useful plants.

5.5 **Energetic use of the physic nut**

The oil of the physic nut seed can be used as fuel and lubricating oil. According to studies in Cape Verde in the 1980s (COSSEL et al. 1982), the oil content of the physic nut is about 25%. This means that four to five kg of seed are needed to produce one liter of oil. Only around 77% of the produced plant oils are useful as fuel; the rest (23%) can be used for soap production (see below).

5.5.1 **Fuel**

The energetic use of curcas oils has increased in importance in recent years and has, in some cases, replaced the use of fossil fuels. However, the price of the plant oil is only competitive in individual cases as fossil fuels are widely subsidized. In general, the promotion of biofuels to prevent greenhouse gas emissions is desirable.

Generally, it is possible to replace diesel oil used in motors with curcas oil by way of two technical alternatives: the oil can be adapted to the diesel motor (esterification) or the motor can be modified so that it may also be run on plant oil. The GTZ has always concentrated on the second possibility (see Chapter 6). In addition, the oil can be used to run lamps and cookers.

Especially in the 1980s, tests were carried out with varying rates of success. The following criteria / conditions must be met:

- Only successful in isolated regions (because the alternative, locally produced sources of energy are available year round and the transportation of mineral oil to isolated regions is often not possible in the rainy season)
- Technical obstacles: it is difficult to produce an appropriate blend; tests with suitable motors had varying success; technically difficult
- Cost of curcas oil exceeds cost of diesel fuel
- Special oil lamps and cookers for plant oils are required (these have a different consistency than petroleum and do not evaporate)
5.5.2 Lubricating oil
Curcas oil has proven useful as a substitute for lubricating oil in diesel motors (Lister type).

5.6 Soap production
Traditionally, soap has been produced from curcas oil in several countries. However, the production process is costly and the quality of the soap is poor. High-quality soap can only be produced with modern production methods. In addition, sodium hydroxide (NaOH) is required and, at times, additional raw materials to improve quality (e.g. tallow, other oils, fragrances). For the local production of simple quality household soap, the following “recipe” was tested in Mali:

“1 l of oil, 1/2 l of water, 150 g of pure NaOH (sodium hydroxide) dissolved in the water. While stirring the oil, the water-NaOH solution is mixed with the oil until a creamy consistency is achieved (like mayonnaise). This is poured into a form, where the soap hardens (in tropical countries overnight, in Europe that may take up to a week). After hardening, the soap is taken out of the form and may be cut into pieces” (http://www.jatropha.de/faq.htm).

5.7 Fertilizer
The press cake can be used as organic, nitrogen-rich fertilizer.

5.8 Minimum local conditions
Experience with use of the physic nut has shown that production for income generation, poverty reduction, and combating desertification is successful when certain local conditions are met (GTZ 2002):

- Training and contact to local suppliers and organizers for local technical support
- When first planting Jatropha, plants adapted to local conditions must be selected and available in sufficient numbers
- NaOH must be available for soap production; additional raw materials for quality improvement, as required
- Simple mechanical oil mills to extract oil
- It must be feasible to operate local motors with plant oil
- High cost of diesel fuel or no continuous local availability (e.g. isolated regions)
6 GTZ’S EXPERIENCE WITH THE PHYSIC NUT

6.1 Fuel production
The energetic use of curcas oil in particular was investigated by GTZ projects in order, among other things, to make erosion protection through the cultivation of physic nut hedges more attractive for farmers.

GTZ’s experience with the physic nut began in the 1980s in the framework of a regional rural development project in Cape Verde. The idea was to make the physic nut, being a largely drought-resistant plant, economically productive.

For Cape Verde, part of the imported diesel oil used in stationary motors and vehicle motors was to be replaced with curcas oil. The project tested the modification of motors, so that these could also be operated with curcas oil. For this purpose, the so-called Elsbett motors were available. However, these were not built in series; each motor was constructed as a prototype and proved costly. The assumption was that high enough levels of demand would permit mass production. However, that never came to pass.

After it became clear that the physic nut component, with its still considerable research and development requirements, exceeded the capacity of the project, this component was spun off and a separate sectoral project was financed by the BMZ.

6.2 The Jatropha System: an integrated approach to rural development
After the project in the Cape Verde Islands showed that this was basically feasible, there was interest in further developing and testing the potential uses of Jatropha. The GTZ implemented a corresponding project in Mali, which brought together the potential uses in an integrated approach to rural development; the so-called Jatropha System was developed.

The project in Mali included the following components:
- Expansion of cultivation as natural fences
- Organization of groups of women who collected the nuts
- Operation of small oil mills by the women’s groups
- Use of the oil on the one hand for the motors of the oil presses, and on the other hand for soap production
- Operation of a project vehicle with plant oil and
- Research into other possible uses of the oil and healthy uses of it

In researching the use and production of the physic nut, there was also cooperation with other scientific institutes.2

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2 There were, for example, various indications in the literature that the oil has a cocarcinogenic effect, i.e. that although it does not itself cause cancer, it does increase the carcinogenic effect of cancer-inducing substances (cooperation with the German Cancer Research Center in Heidelberg). With the Institute of Pharmaceutical Biology of the University of Heidelberg, components of the oil were successfully investigated to determine their insecticide and molluscicide effects. With the University of Hohenheim, the use of press cake as fertilizer was also successfully researched.
After two years, the BMZ evaluated the project in Mali. The results show that, despite technical feasibility, there is little chance the project approach will be accepted by the population because it is not profitable. One liter of fuel derived from curcas oil costs twice as much as a liter of diesel fuel (see EUSSNER et al. 1997). The curcas oil produced was scarcely used as fuel (except for the motors of the oil presses); instead, it was used almost exclusively for soap production. Because the manufacture and use of curcas oil as fuel was unprofitable the project was not sustainable, i.e. without continual monetary subsidies from development cooperation it could not survive. In addition, it was shown that the profit ratios had been considerably manipulated. Realistic estimates showed that it had not been possible to achieve profitability for use of curcas oil as a substitute for diesel oil, irrespective of the already mentioned technical problems. Private use of the technology to produce fuel is thus unrealistic. The project was discontinued in 1997, ahead of schedule.

Parallel to the project in Mali, an Austrian cooperation implemented an alternative concept in Nicaragua: plantation cultivation of the physic nut, central esterification of the oil, and use in only slightly modified diesel motors. This project also failed because of lack of profitability and the unwillingness of oil companies to offer an alternative fuel.

(B. BOHNSTEDT; E. DUDECK; EUSSNER et al. 1997)

6.3 Producing soap based on curcas oil

In the framework of integrated development measures for the Cape Verde islands of Fogo and Brava, the use of the physic nut to make soap was also tested. The Cape Verdean soap market is 100% dependent on imports. However, curcas-oil-based household soap that is of the same quality as the imported soap cannot be produced locally without considerable technical input. Toilet soap cannot be made with curcas oil. Curcas oil can be made into household soap of mediocre quality using a blend of 27% curcas oil and 73% other soap raw materials. To produce 1,000 t of soap, about the same volume of nuts is required. All other raw materials for soap production (tallow, other oils, sodium hydroxide, fragrances) must be imported.

The rural development project on Fogo and Brava began by investigating the possibility of building up a domestic soap industry. The project component failed already in the study phase because of lack of profitability. This was the result of high industrial production costs due to the limited size of the market and the related inefficiency of small production facilities, but also to the import costs of the other soap raw materials required.

The small size of the market, the poor quality of physic nut soap, and the fact that all required raw materials except curcas oil must be imported are also obstacles for local, decentralized soap production.

(COSSEL et al. 1982, GTZ/RUDECO 1987)
7 RESULTS

1. In general, there are varying opinions on and experiences with the suitability of the physic nut to combat desertification and reduce poverty. Previous projects in Cape Verde and Mali were discontinued because of the unprofitability of physic nut production under current conditions (e.g. crude oil price). Nevertheless, careful site analysis and macro- and micro-economic calculations are required for every location where use of the physic nut is planned.

2. The available economic analyses (except for DEMANT & GAJO 1992) did not carry out micro- or macro-economic calculations of the ecological benefits, particularly erosion protection and reclamation of arid areas.

3. The use of the physic nut to produce oil (fuel, soap production, insecticide) requires high levels of technical input, considerable investment, know-how (processing, harvest, care of trees, etc.), and precise analyses (e.g. market, local conditions).

4. Particularly for small-farmer production systems and decentralized utilization, costly harvest and processing procedures, marketing difficulties, and socio-cultural factors stand in the way of optimal utilization.

5. Use as a substitute for diesel has no prospects under present framework conditions for technical, economic, and organizational reasons. It might be possible to use oil produced in decentralized locations in a large, central motor (power plant) and to simultaneously commercialize the by-products (fertilizer, insecticide), because then at least most of the technical problems could be solved more easily. However, it would probably make more sense to burn all the nuts and use the energy. But even that would require detailed macro and micro-economic studies especially taking into account local conditions.

6. Intensification of physic nut production is possible on the island of Fogo. An appreciable numbers of groves are still found there, although they are in very poor condition due to their many years of use as a source of firewood. Nevertheless, through targeted care and regeneration these could be channeled into seed production. On the other islands, there are not enough groves for renewed intensification of physic nut production, since these have been largely cleared due to the shortage of firewood. Here the only possibility is replanting. The cultivation of physic nut for seed production must always be preceded by the production of sufficient firewood.

7. The annual seed yield from the old groves is estimated to be very low, even on Fogo. Systematic replanting and care of the groves can be expected to significantly raise seed production after five years at the earliest.

8. Soap production, whether organized centrally/industrially or decentrally/locally, appears to promise little success even in the future: the poor quality of physic nut soap, high costs for additional raw materials, and marketing difficulties are the main deficits.
8 SUMMARY AND RECOMMENDATIONS

The physic nut is certainly a highly interesting plant with potential uses, particularly as biofuel. In Cape Verde, a number of theoretically required conditions are met. Curcas oil utilization is basically feasible from a technical point of view. However, the multi-faceted use of Jatropha requires diversified agricultural production and processing of the plant, a great deal of organizational and technical input, and markets.

Previous GTZ experience has demonstrated the limits of trying to harness physic nut potential: the use of curcas oil, both as a substitute for diesel and also in soap production, was assessed as unprofitable. The projects were viewed as unsustainable with little willingness of the population to accept them. Non-technical aspects of the Jatropha System, such as the promotion of women and poverty reduction, thus could not be implemented. If a feasibility study also calculates the use of the physic nut as erosion protection and the use of the press cake as fertilizer, the balance will certainly be positive; however, there remains the population’s unwillingness to accept it as a direct source of income.

On the basis of existing knowledge and experience, the utilization of the physic nut under present framework conditions in the particular socio-economic environment of Cape Verde is not profitable and without subsidies, e.g. through development cooperation, not feasible. Thus, positive effects such as poverty reduction or amelioration of desertification effects cannot be achieved in the long term.
9 SOURCES OF INFORMATION

Documents / literature


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Interviews / e-mail contacts

Mr. Bengt BOHNSTEDT, GTZ El Salvador, officer responsible for the project “Use of Plant Oil as Fuel” (1987.2227.4)

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