left: *Hypsiboas raniceps* frog in a plantation of guava. (Photo: Maike Guschal)
right top: Bug feeding on local *umbu* (*Spondias tuberosa)* fruit. (Photo: Maike Guschal)
right below: Typical tree plantation (coconut) of the region (Photo: Maike Guschal)

Biological pest control through promoting habitats for native fauna

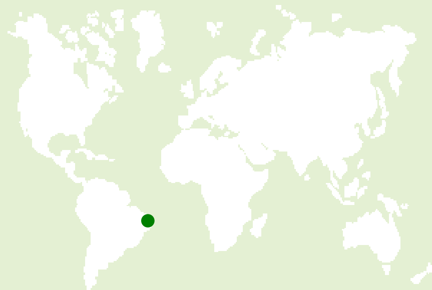
Brazil - *Controle biológico de pragas pela fauna nativa: manter ou restabelecer habitats respectivos*

Reducing the use of common agrochemicals by supporting preferred habitats of biological pest control agents like amphibians and by using alternative self-made organic pesticides.

Irrigated crops attract various pest species. Farmers usually address crop pest and disease problems through the use of agrochemicals. Especially bees, birds, and amphibians, which fulfil important functions in agroecosystems, are affected by high use of agrochemicals. The combination of inappropriate irrigation practices, incorrect application rates of agrochemicals, and low producer prices often lead, however, to poor income from smallholder irrigated agriculture and to further problems such as poor health, loss of biodiversity, and soil and water contamination. Amphibians are themselves proven biological pest control agents of arthropod pest species (predators of e.g. larvae of butterflies, beetles, termites, bugs and others) and the incorrect use of agrochemicals, as well as the removal of vegetation along field margins hampers this useful function. The technology described here aims to support and utilise the potential of amphibians (such as frogs and toads) as biocontrol agents –as an alternative to agrochemicals in crops.

Establishing habitats for amphibians is crucial in order to increase and secure their numbers: for example encouraging shrubby vegetation next to water bodies for arboreal frogs, and installing additional water ponds inside and around plantations for ground-living frogs. First, the local species pool of amphibians needs to be determined by visual and acoustic observations. Amphibian species do not need to be determined precisely, but it is important to detect whether they are arboreal and/or ground-living amphibians, as these two groups have different roles as biocontrol agents. Pests that feed on the main cultivated species should be characterized by (a) collecting plant material to determine the type and quantity of pests and (b) by comparing observations with neighbouring farmers and extension agents. Pest species can be determined also by installing traps and using nets. Inspection should be done at least every 15 days to once a month during the whole rainy season to detect possible mass reproduction of arthropods after rainfall events. Once amphibians and pest species are detected, decisions on management strategies can be made. Such a strategy is to create habitats for amphibians with additional sources of income, e.g. by planting pomegranate or guavas as shrubby vegetation structure for arboreal frogs. If pest species can't be reduced solely by amphibian species, the use of agrochemicals has to be reconsidered. Preference shall be given to chemicals which do not harm amphibians. Organic, self-made pesticides based on the extract of manioc roots (*manipoera*) seem promising. Twenty litres of *manipoera*, the bark of manicoba tree (*Manihot pseudoglaziovii*), a cup of American wormseed (*Dysphania ambrosioides*), a cup of yellow tagetes (*Tagetes sp.*), a cup of malagueta pepper (*Capsicum sp.*), garlic and a little bit of bleach have to be chopped, mixed and fermented for 10 days. Application of the final product (25 ml of organic pesticide diluted in 20 l of water) should be done every 8 to 15 days depending on crop species.

Increasing habitat heterogeneity stimulates the diversity of amphibians and so a greater number of pest types will be controlled. Combined control by safeguarding natural amphibian habitats and application of organic pesticides is an innovative alternative to the overuse of toxic agrochemicals.



Location: Floresta, Itacuruba, Petrolandia
Region: Brazil, Pernambuco
Technology area: 0.1 - 1 km^2
Conservation measure: vegetative, structural, agronomic
Stage of intervention: prevention of land degradation, mitigation / reduction of land degradation
Origin: developed through experiments / research, traditional (>50 years ago)
Land use type: cropland: perennial and annual cropping; grazing land: Intensive grazing/ fodder production
Climate: semi-arid, tropics
WOCAT database reference: T_BRA010en
Related approach: none
Compiled by: Maike Guschal, Museum of Zoology, Senckenberg Natural History Collections Dresden, 01109 Dresden, Germany, e-mail: maike.guschal@gmail.com
Date: 1st January 2015, updated June 2016

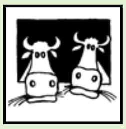
INNOVATE

Classification

Land use problems: Intensive livestock grazing pressure, agriculture and logging of native vegetation are the driving factors behind loss of the Caatinga dry forest. The high use of agrochemicals additionally pollutes soils and watersheds, and probably also decreases local biodiversity. Droughts seem to occur more frequently and these decrease water and food availability for livestock, as well as affecting the local fauna (expert's point of view). Droughts and consequently problems of feeding livestock on natural vegetation (lack of fodder and grazing grounds), deforestation, extensive and inappropriate use of agrochemicals, low producer prices (land user's point of view).

Land use

perennial (non-woody) &annual cropping; , tree and shrub cropping;



intensive grazing / fodder production, mainly irrigated

Climate

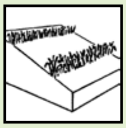
semi-arid

Degradation

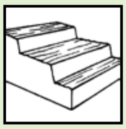
biological: loss of habitats; diversity decline; loss of predators; increase of pests/diseases

water: change in quantity of surface water

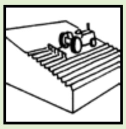
Conservation measure



vegetative: grasses and perennial herbaceous plants; tree and shrub cover



structural: water ponds



agronomic: vegetation / soil cover, organic chemicals for pest control

Stage of intervention

Prevention
Mitigation / Reduction
Rehabilitation

Origin

Land user's initiative: traditional (>50 years ago)
Experiments / research: traditional (>50 years ago)
Externally introduced: recent (<10 years ago)

Level of technical knowledge

Agricultural advisor
Land user

Main causes of land degradation:
Direct causes - Human induced: crop management (annual, perennial, tree/shrub), deforestation / removal of natural vegetation (incl. forest fires), overgrazing.
Direct causes - Natural: change in temperature, change of seasonal rainfall, Heavy / extreme rainfall (intensity/amounts), droughts.

Main technical functions:
- improvement of ground cover
- increase of biomass (quantity)
- improve habitat and habitat diversity
- promotion of vegetation species and varieties

Secondary technical functions:
- increase / maintain water stored in soil
- increase in nutrient availability (supply, recycling,…)
- increase of surface roughness
- stabilization of soil (e.g. by tree roots against landslides)
- increase in organic matter

Environment

Natural Environment

Average annual rainfall (mm)

> 4000
3000-4000
2000-3000
1500-2000
1000-1500
750-1000
500-750
250-500
< 250

Altitude (m a.s.l.)

> 4000
3000-4000
2500-3000
2000-2500
1500-2000
1000-1500
500-1000
100-500
<100

Landform

plateau / plains
ridges
mountain slopes
hill slopes
footslopes
valley floors

Slope (%)

flat
gentle
moderate
rolling
hilly
steep
very steep

Soil depth (cm)

Not relevant

Growing season(s): permanent water source: the whole year; temporary water source: January to May
Soil texture: coarse / light (sandy)
Soil fertility: low, very low
Topsoil organic matter: medium (1-3%), low (<1%)
Soil drainage/infiltration: medium, poor (e.g. sealing/crusting)

Soil water storage capacity: low, very low
Ground water table: around 50 to 80 m deep
Availability of surface water: poor/none
Water quality: poor drinking water
Biodiversity: medium, low

Tolerant of climatic gradual change and extremes: temperature increase, seasonal rainfall increase, wind storms / dust storms, floods, decreasing length of growing period
Sensitive to climatic gradual change and extremes: seasonal rainfall decrease, heavy rainfall events (intensities and amount), droughts / dry spells. Abundance of amphibians is likely to increase with higher rainfall quantity and intensity, this probably results in better pest control. In case of frequent droughts, reptiles like lizards become more important as they do not depend so much on rainfall.

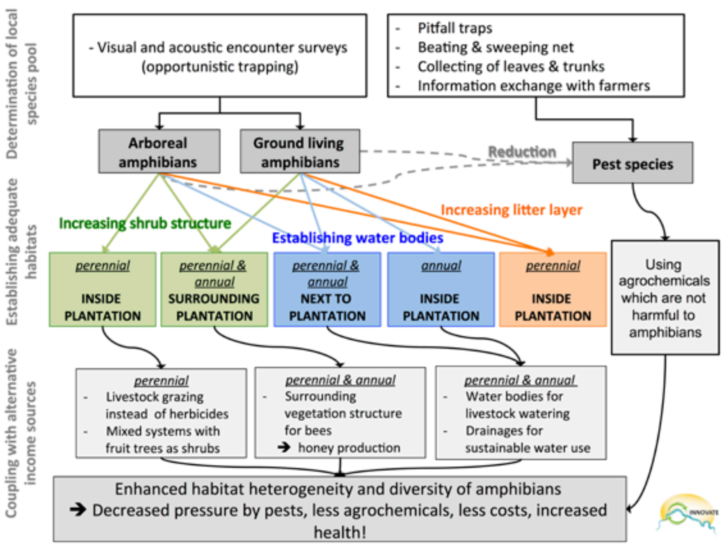
Human Environment

Cropland per household (ha)

- <0.5
- 0.5-1
- 1-2
- 2-5
- 5-15
- 15-50
- 50-100
- 100-500
- 500-1,000
- 1,000-10,000
- >10,000

Land user: Individual / household, medium scale land users, average land users, men and women
Population density: 10-50 persons/km^2
(All types of Land ownership and land use rights can be found in the study region)
Annual population growth: 1% - 2 %
Land ownership: State
Land use rights: Individual
Water use rights: Needs official registration and permission; heavy water use has a price
Relative level of wealth: Average

Importance of off-farm income: 10-50% of all income: the same, there are just single farmers who use the technology currently.
Access to service and infrastructure: Low: technical assistance, employment (off-farm), drinking water and sanitation, financial services; moderate: health, education, market, energy, roads & transport.
Market orientation: subsistence (self-supply), mixed (subsistence and commercial)
Mechanization: low to no
Livestock grazing on cropland: low, should be more focused in future



Technical drawing

Vegetation structures surrounding plantations beside waterbodies guarantee the occurrence of arboreal and ground-living amphibians. Arboreal frogs prefer shrubby vegetation. Since mowing or application of herbicides often eliminates shrubs, moderate livestock grazing might be a better option. The additional water bodies outside the plantation can thereby be used for livestock watering, as long as the surrounding vegetation structure is not eliminated through grazing. Fruit trees such as Guava or Pomegranate as shrub structure provide an additional source of income. To ensure the presence of ground-living frogs, smaller water bodies must be promoted within the plantation. Here puddles from leaky irrigation systems seem to be sufficient already.
Only agrochemicals and organic pesticides that are harmless to amphibians should be used as additional chemical pest control.(M. Guschal & L. Steinmetz)

Implementation activities, inputs and costs

Establishment activities

Establishing habitats for the pest-controlling amphibians

1. Installing of additional small and large water bodies:
   a. large ponds outside the plantation (~100 m²/pond, ~ 4 ponds/plantation, one working day per pond)
   b. smaller ponds for ground-living frogs inside the plantation (one working day/ 5 ha).
   c. drainages can be installed instead of ponds outside the plantation for sustainable water use (machine rent)
2. Planting shrubby vegetation or fruit trees outside and inside the plantation. Planting of Guava trees as shrubby vegetation: 25% density compared to Guava monoculture (e.g. 1.25 working days for exclusive Guava plantation)
3. As irrigation was free in the study region, there were no costs calculated.
4. Knapsack sprayer for application of pesticides

Establishment inputs and costs per ha

Inputs	Costs (US$)	% met by land user
Labour		
– constructing of large ponds	~ 36.00	
– constructing small ponds	~ 01.80	
– planting 100 Guava trees/ha	~ 11.25	
Equipment		
– rent of machine for pond or drainage ditch excavation	~ 100.00	
– knapsack sprayer	~ 90.00	
Agriculture		
– fruit tree seedlings (100)	~ 75.00	
TOTAL	**~ 314.05**	**100 %**

Maintenance/recurrent activities

1. Monitoring amphibian species at least 3 nights in the rainy season (can be done by the farmer himself)
2. Monitoring of pest species (1 hour/ha) at least every 15 days in the rainy season (5 month/year) and once a month in dry season (7 month/year) (can be done by the farmer himself)
3. Production and application of organic pesticides (25 ml of organic pesticide diluted in 20 l of water and applied every 8 to 15 days). Note: for commercial pesticides the application costs are the same.
4. Application of fertilizer (1 working day/ year)
5. Pruning of trees (5.25 working days(/year)

Maintenance/recurrent inputs and costs per ha per year

Inputs	Costs (US$)	% met by land user
Labour		
– monitoring of frogs	~ 27.00	
– monitoring of pest species	~ 18.00	
– production and application of organic pesticide	~720.50	
– pruning	47.25	
– fertilizer application	~ 9.00	
TOTAL	**~ 821.75**	**100%**

Remarks: To calculate the above example a scenario with maximum activities was taken. Any other scenario will be cheaper. Prices are from the year 2013. Real 1 = USD 0.3.. A total of 6 liters of concentrated organic pesticides per hectare per year are needed. This applies for both self-made and commercial pesticides. As commercial organic pesticides cost about USD 36 per liter, farmers spend USD 216 less per year for self-produced organic pesticides. Similarly commercial non-organic pesticides are more expensive compared to self-made organic pesticides. An additional income of USD 120 / ha / harvest were estimated for guava trees even under possible poor conditions like shadow and extensive management. Other additional sources of income are from the sale of self-produced organic pesticides and livestock grazing instead of using herbicides.

Assessment

Impacts of the Technology

Production and socio-economic benefits

- ++ reduced expenses on agricultural inputs
- ++ diversification of income sources
- \+ increased crop yield
- \+ increased fodder production

Production and socio-economic disadvantages

- − reduced livestock production (high number of livestock will decrease favourable vegetation structure for predators)
- − loss of land

Socio-cultural benefits

- \+ reduced pesticide toxic effect on human health

Socio-cultural disadvantages

Ecological benefits

- +++ increased animal diversity
- +++ increased plant diversity
- +++ increased biological pest / disease control
- +++ increased / maintained habitat diversity

Ecological disadvantages

- − increased niches for pests

Off-site benefits

- +++ reduced downstream flooding

Off-site disadvantages

Contribution to human well-being/livelihoods

- +++ less use of agrochemicals

Benefits/costs according to land user

Benefits compared with costs	short-term:	long-term:
Establishment	negative	positive
Maintenance/recurrent	slightly negative	positive

Acceptance/adoption:
Technology is still in the testing phase and it is too early to give any data on acceptance or adoption.

Concluding statements

Strengths and → how to sustain/improve

A strong advantage is the low cost of this ecosystem service which is provided almost freely to farmers, especially when the potential for pest control (abundancy of useful amphibians) is high enough to eliminate the need for agrochemicals → Establish adequate habitats to maintain high diversity of the relevant reptiles and amphibians.

Less use of agrochemicals results in a healthier environment for producers and consumers → If the potential of the reptiles and amphibians is not high enough to combat all pest species, organic chemicals or alternative biocontrol species could be used (for example horntails etc.).

Changing monoculture to mixed systems - or even agropastoral systems - offers additional income sources, while diversification often as a buffer to sudden drops in the price of a particular crop → The crop mixture needs to be well designed, to ensure that the harvests of important crops are not affected too much, and the reduction compensated for by the others.

Weaknesses and → how to overcome

Droughts and limited water availability influence species richness of amphibians → Providing sufficient water bodies for amphibians to overcome prolonged droughts is recommended.

Key reference(s): Guschal & Hagel et al. Benefits of site-adapted management (pest-control) innovations in northeastern Brazil. In preparation.
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