CATTAIL (TYPHA AUSTRALIS) AS AN INNOVATIVE INSULATION AND CONSTRUCTION MATERIAL FOR INDUSTRIAL AND DEVELOPING COUNTRIES

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ABSTRACT: After the independence of Senegal, Mali and Mauritania it was decided to build a huge hydroelectric dam in Manantali, Mali. This dam provides irrigation water for the semi desertic region along both banks of the Senegal River. As consequence the water level of the Senegal River does not change more then about 50 cm, whilst in former times the difference between high and low water levels could easily be 15 meters. As an unforeseen and completely underestimated effect, the native plant Typha australis called as well cattail, disseminated with an unbelievable speed. It grows nowadays with about 100.000 t dry matter per year. Typha blocks therefore the water flow in irrigation channels, hinders fishermen, give shelter to birds which harm the rice yields and causes much waterborne disease, mainly Bilhazosis and Malaria. All attempts to destroy Typha were in vain. Therefore the GTZ-PERACOD-Programme, executed in behalf of the German Ministry BMZ and the Senegalese Ministry of Energy and Mines developed schemata to use Typha for the production of bio-coal and as insulation and construction material. A lot of research and development was done to foster the topics. Nowadays all elements to describe the problem and propose solutions are available. Senegal is preparing requests to important donors.
Keywords: Typha australis-cattail, construction + insulation materials, Senegal.

1 THE PSACD-PERACOD APPROACH TO TYPHA AUSTRALS AS SOURCE FOR ENERGY AND CONSTRUCTION AND INSOLATION MATERIAL

After the independence of the West African states Senegal, Mali and Mauretania in the beginning of the sixteenths in the last century, they planned to build a huge hydroelectricity Dam and to use it regionally. Finally the dam was constructed in Manantali in Mali. The idea was to manage the water regime of the Senegal River for irrigation purposes in the three countries and later for electricity generation too. A second, much smaller weir was construction in Diama, near Saint Louis in Senegal. Before the construction of the dams the difference between high water levels during the rainy season and low level at the end of the dry season could reach more than 15 Meters. Nowadays the difference is not more than 0.5 Meter. All this was a sort of unforeseen kick off program for the dissemination of Cattail (Typha australis). Typha is an autochthonous plant which grows on the Senegal riverbanks. Due to the new favourable conditions Typha has spread meanwhile to over than 100.000 ha and has a reproduction rate of about 10 % per year. This makes that the former already used plant became a threat for biodiversity, cause of waterborne illness and danger for irrigation purposes [1].

1.1 Request by donors of the Senegalese government

In the early 1990 the Senegalese government launched a request to the international donor community to assist Senegal in solving an urgent problem concerning biomass and energy. Senegal loose every year about 45.000 ha on forests areas because of new dwellings due to still a high birth rate with 2.7% and for firewood and charcoal production and bushfires. The Senegalese request was favourably answered by the German government represented by the BMZ (Federal Ministry of Cooperation and economic Development) and the World Bank. In 1995 GTZ (Deutsche Gesellschaft für Technische Zusammenarbeit) started its activities in behalf of the BMZ, jointly with the World Bank Project "PROGEDE" (Programme pour la Gestion Durable et Participative des Energies Traditionnelles et de Substitution). The first GTZ-Project was called PSACD (Projet Sénégalo-Allemand Combustibles Domestiques) which was followed in 2004 by the PERACOD. Both programmes e.g. PROGEDE and PERACOD are jointly executed by the Senegalese Ministry of Energy and Mines and DEFCCS (Direction des Eaux et Forêts, Chasses et Conservation des Sols) and of the Environmental Ministry. PERACOD has a joint cooperation within the EU-COOPENER Programme called MEPRED (Mainstreaming Energy for Poverty Reduction and Economic Development into EU Development Assistance).

1.2 Approach

In 1997 PSACD started with a survey of biomass resources in Senegal for carbonisation purposes to lower the pressure on remaining forests. In the North of Senegal rice husks and Typha was found as being resources for energy production [2]. From the very beginning Typha was considered however as well as a high potential insulation and construction material.

Typha is vitally used in the local handicraft sector and as well as construction material but just in the sense of nuts and fences. The direct energy use and the indirect one via its insulation properties went always hand in hand. Typha has enormous insulation capabilities due to its natural structure and equals with high performing synthetic materials known and used in industrialized countries. It was obvious therefore to study possible application for insulation and construction in cities. [3]. About 40% of the electricity produced in Senegal is used for air conditioning and in 2004 about 1.100.000 t crude oil were imported for electricity production.
In 2006 a relative large and important Workshop was held in Dakar [4]. The R&D results till then were reported. The Senegalese Government expressed its interest in executing such a project. Preparations for donor meeting are underway.

1.3 Scientific innovation and relevance

Several studies were made, meetings and workshops organized and the biological, physical and chemical properties studied. Harvest and Typha management schemes were developed. Different materials and components were tested. There is a tremendous know how about Typha available worldwide, because that plant grows on several climate zones and continents, thus a technology transfer was applied.
The research programme was accomplished by the Universities of Munich/Germany and Dakar/Senegal and as well the private sector and architects associations and experts in Germany, France, Austria [5] and Senegal.
The chosen approach and its positive results are of high interest for the international developing aid, but as well for scientists of various disciplines and especially for the Ministry of Energy and Mines and the private sector. The insulation material could be fabricated in Senegal.
The achievement how to convert a local available naturally growing material in income generating activity could be applied in various other Sahelian countries and other countries world wide with similar natural sources.

2 THE COUNTRY SENEGAL

2.1 Geographical situtation

Officially the Republic of Senegal (Fig. 1), Senegal is a country south of the Sénégal River in western Africa. Senegal is bounded by the Atlantic Ocean to the west, Mauritania to the north, Mali to the east, and Guinea and Guinea-Bissau to the south. The Gambia lies almost entirely within Senegal, surrounded on the north, east and south; from its western coast. The Gambia's territory follows the Gambia River more than 300 kilometres inland.
The Cape Verde islands lie some 560 kilometres off the Senegalese coast, but Cap Vert is a peninsula near Senegal's capital Dakar, and the western-most point in Africa.
The Senegalese landscape consists mainly of the rolling sandy plains of the western Sahel which rise to foothills in the southeast. Here is also found Senegal's highest point, an otherwise unnamed feature near Nepen Diakha at 581 m. (1906 ft.) [6]

Figure1: Map of Senegal

2.2 The city of Saint Louis

Capital of the former French Western Africa from 1895 to 1902, and capital of Senegal until 1958, Saint-Louis became the leading economic, commercial, artistic and urban centre of sub-Saharan Africa during the 1700's. Today, rich in three centuries of history, in cultural background, geography, architecture and many other characteristics, Saint Louis is a bridge between the savanna and the desert, the ocean and the river, tradition and modernity, Islam and Christianity, Europe and Africa. Home to a society with a distinctive lifestyle, Saint-Louis has retained its unique identity. "No one comes without falling in love with the city," proudly say its people who consider Saint-Louis as the birthplace of Senegalese Teranga, the Wolof word for hospitability. [7]
Founded on St-Louis Island, the city has long spread on to the Langue de Barbarie spit, home to the districts of Ndar Tout and Guet Ndar, right up against the Mauritanian border at the north end and home to the fishing port and main market. The city has also spread on to the mainland, where the district of Sor is home to the seldom used train station. Half the distance of the Langue de Barbarie spit a break through had been dug between the Atlantic Ocean and the Senegal River in the year 2000 what caused a dramatic change in the biosphere of that ecological very interesting landscape.

2.3 The Senegal River

Senegal River is a 1,800 km long lifeline in the Sahel shared by four nations: Guinea, Mali, Mauritania, and Senegal. The rainy uplands of Guinea are the source of a major part of the river water. It is then conveyed through the lowlands, which become increasingly arid towards the mouth of the river.
The river and the surrounding valley have supported its population variably through the centuries in the harsh and highly variable climatic conditions. The traditional livelihood methods and ways of using the river in cyclical matters have been the only possible way until the introduction of modern agriculture in 1950s to the valley.

Through the history there has been a high frequency of dry climatic periods, which has forced people to leave the valley, causing mass starvation and conflict. The last few decades have seen an augmentation of various problems in this fragile valley. Severe droughts have hit the region, the population growth rate has been extreme, the economy has declined, food security has been unstable, and, consequently, there have been numerous mass migrations, mainly to the mushrooming cities such as Dakar, Bamako, Conakry and Nouakchott. Since the last five decades, the river has been seen as a means of enhancing the national economies of its member states. An attempt at food self-sufficiency, boosted by the problem of feeding the growing urban population and the possibility of future droughts, are the major driving forces of some national and international organisations. Large-scale schemes for modernizing agriculture, hydropower generation, and enabling navigation are listed as the major means of supporting such attempts [8].
Senegal pumps in the city named Richard Toll about 1/3 of Dakar's water consumption out off the Senegal river into the Lac de Guier (see section 3.4), from where it is transported in huge Ferro-cement pipes to Dakar and other locations a long it's way south.
From Matam, the first town on Senegalese border with Mali, Senegal River flows westwards and separates the two States Senegal and Mauritania. The landscape and vegetation on both banks are the same. The main agricultural product on both sides of the river is rice. There is on the Senegalese side in the city of Richard Toll as well sugar cane production. Near Saint Louis a weir called Diama, was constructed. The water level between Manantali and the Saint Louis weir is more or less constant throughout the year and that is exactly the purpose of the water management by the OMVS. Smaller weirs and canals and water pumps guaranties the almost same water level for paddy rice production [9]. Only since the construction of the Manantali Dam the situation has changed dramatically. The influence of the seasons on the height of the water level is minimal. Superb conditions for Typha. On could argue that the dam was built for Typha proliferation.

3 THE MANANTALI DAM

3.1 What is the manantali dam?

The Manantali Dam is a hydroelectric dam on the Bafing river, 90 km to the south-east of Bafoulabé, in Mali's Kayes Region (14°21′00″N, 11°20′30″W). The Bafing River is a side arm of the Senegal River. It is managed by the Organization for the development of the Senegal River (l'Organisation pour la mise en valeur du fleuve Sénégal, or OMVS). The dam irrigates 2,550 square kilometres of land and maintains the navigability of the Senegal River between Saint-Louis, Senegal and Ambidédi, Mali. The states Mali, Senegal and Mauretania are represented in the OMVS. Construction on the dam began in 1988, but a World Bank loan was required before the turbines could be installed; the dam provided its first megawatt of electricity in 2001. The dam has proved controversial for its displacement of local villages from the flooded area, and its health and environmental impacts [10].
There is an electrical grid-connection from Manantali to Senegal. About 65 MW are fed into the Senegalese electricity distribution network [11].

3.2The role of SAED

The key institution for managing the agricultural scheme in the Senegal river-valley is called SAED: Société nationale d'Aménagement et d'Exploitation des terres du Delta du fleuve Sénégal et des vallées du fleuve Sénégal et de la Falémé – National Society of Farming and Soil Exploitation of the Delta of the Senegal River and the Valleys of the Senegal- and Falémé Riverbelt. [12].
The SAED promotes the policy of highly-mechanized irrigated rice farming on a large-scale (fig. 2). Its focal area was on the river delta and there were very few activities upstream.
The Senegal River development schemes in their modern form date back to early 1970s when OMVS - the river organisation of Mali, Mauritania, and Senegal - issued its management plan [13]. It included three components: irrigation, navigation, and energy.
At the same time, the SAED extended irrigation activities from the Delta to the river valley. Small irrigation schemes, PIVs (périmètres irrigués villageois), were implemented in villages. PIVs were successful during the drought years, since material and equipment were provided for the farmers free of charge. Yet, when support from the state ended, the schemes failed to fulfil their goals and the costs exceeded the benefits.
SAED provides nevertheless professional and specific know-how concerning the management of Typha, sustainable water management and appropriate construction techniques. SAED aims to preserve the hydro-agricultural tradition in the target region and to intensify its agricultural activity. It is an open-minded organisation with important linkages to local decision-makers [14] & [15].

3.3 SAED and Typha

Since the construction of two dams at the Senegal River there is a strong growth of Typha concerning the whole river basin and the Lac de Guier. The plant displaces former water areas, blocks irrigation canals and the physical access to water with negative effects on hygiene and health [bilharzia, malaria]. It reduces fish reproduction and rice crops production. Consequently Typha is permanently removed by SAED causing enormous expenses and tons of unused biological "waste". At the same time there is a lack of available building materials.

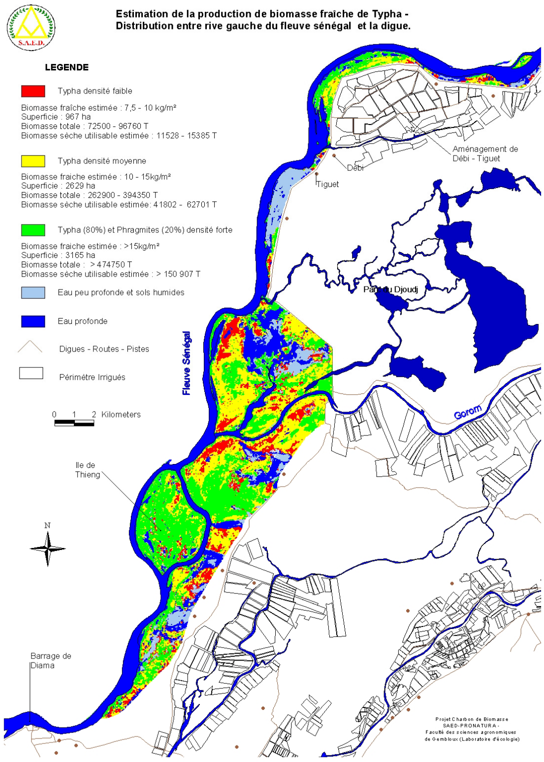

Figure 2: Map of the SAED Irrigation-Territory

3.4 The Lac de Guier

South of the town of Richard Toll the Lac de Guier is situated. It is the largest lake of the basin in northern Senegal. As the sole water reservoir in the lower Senegal River basin, it is extensively used as a stable fresh water source throughout the dry season, which lasts nine to ten months a year. On the top of growing national needs, the local population grows very fast; by 2.8 times in 25 years, which is much above the regional average. Lac de Guiers has the mean depth of 2 m, length 50 km, and breadth 6 km. Until 1986, it was filled by low-saline water of the Senegal river during the rainy season floods. During the dry season, seawater entered the lake causing a sharp increase in salinity. The volume of the lake fluctuated each year from 500-600 million m3 during the flood season to 50-70 million m3 towards the end of the dry season. This pattern was dramatically altered by the construction of the Diama dam, which is located in the river between the lake and the river mouth. It can be used to control and prevent the intrusion of saline water upstream to Lac de Guiers. Consequently, the salinity of the lake water has been stabilized and decreased after the dam was put into operation. Changes in the lake's water quality and ecosystem, together with an increased use pressure triggered a need for an improved management and the analysis of the impact of alternative management options [16].

The lake consists of four distinct regions. The northern one, heavy loading from 8,000 hectares of irrigated sugar cane plantations, has particular macrophyte development problems, and limited eutrophication problems. The central region is the present source of water withdrawal to Dakar and the southern region and the Ferlo basin.

During the planning and construction phase of the Manantali Dam and the Diama weir and as well later during the implementation of the irrigation schemes in the SAED area, nobody took Typha as serious threat to any kind of application. Typha australis is a native plant. The water weed Typha grew since ever near the banks of the Senegal River – System, was used by the local population for handy craft purposes [17].

Typha however is a very strong plant, it can germ in aerobic and anaerobic condition. Typha grows everywhere where the plant finds proper conditions. That's make that Typha grows at all riverbanks and irrigation channels and thus stops the flow of irrigation water. It overwhelms all other plants and disturbs heavily any ecological equilibrium.

Typha grows every year with a nearly unbelievable speed. It is supposed that every year additionally 100.000 t of dry matter are added [18]. It therefore essential to find a proper way of Typha utilization and that was found by harvesting it in large quantities; treat it as insulation material for many purposes in cities and country side.

4.1 Harvesting the typha

Typha can be harvested (fig. 3) from the steady land, in swampy areas and from the water front. Due to hardly any change of the water level of the Senegal River Basin the swampy area does not fall dry occasionally and thus Typha can hardly be harvested by that manner.

Figure 3: Cultivated surfaces in Donaumoos near Munich [www.typha.net]

4.1 Harvest Typha by boot from the river side.

Rolf-p. Owsianowski, the author of this article, has proposed as consequence of this situation, to harvest Typha by boot from the river side. He designed a water-jet-stream puls - pomp to cut the Typha stems. It was found that with about 2.7 bars water pressure, Typha stems can be cut.

4.2 Utilisation of the Thypa rhyzom

In case the Thypa rhyzom, which contains appropriate starchy components, are required as gluey material in the bio charcoal production, Typha can be lifted completely with appropriate lifter. Rolf-p. Owsianowski designed such lifters which work however only in sandy grounds of the Senegal River. Three forks of the lifter go in the sandy river belt beneath the roots and rhyzom. With help of the water jet-stream all sandy material is washed away so that the roots and rhyzom can be lifted. Typha stems float by it self and can be harvested easily, The Typha harvested by that technique has a superb quality and stems and leaves of about 4 meter length. For quite a few applications Typha leaves should be dry. Therefore drying advices have to be implicated [19].

5 TYPHA AS BULDING AND INSULATION MATERIAL

Concrete is omnipresent but lacks complementary materials and appropriate processing on site in Senegal. Missing heat insulation reduces extremely the comfort of buildings. Additionally cooling devices cause enormous energy consumption and expenses. There's a lack of ecological know-how and sound national standards.
Presently the authorities of the Senegal Delta face the overgrowth of Typha with constant annihilation.
However, this permanently regrowing material has the potential of being a valuable raw material for two of the most important factors of human life: energy and housing. The proposal is based on the latter: Typha as naturally renewable basis for building materials [20] & [21]

5.1 Different types of Typha application

The idea is to reverse the problem into benefit, hence to use this rapidly growing biomass (100.000 t/y dry matter) as basis for building materials in a region where other construction materials are rare or totally lacking.
There is a wide spectrum of promising Typha products:
>> composites with cement [bricks, roof panels, etc.],
>> panels for heat/cold insulation,
>> beams, fences,
>> carved shaped elements for traditional housing, roof and walls,
>> any type of baskets,
>> small containers for transporting fragile or organic materials like fish, crabs, langoustines, meat etc…
Local production will support economic growth of the region and the establishment of new forms of income based on a sustainable management of permanently harvestable biomass. Hence it fights poverty by job creation and by raising the general standard of living: Safe and comfortable housing will be available for the poor.
Concerning the environment the sustainable use of Typha reduces the problems caused by its overgrowth. Our approach detects and activates unused potential of development within an existing system itself.

5.2 Innovation

The idea is truly quite innovative and unique. The approach differs from existing approaches and is it potentially more effective.
The crucial idea is to reverse a profound ecological problem with negative impacts on health and everyday life into a new chance of sustainable livelihood: By using Typha as basis for everyday needs like housing it loses its threatening dimension and becomes a specific chance for the region. The existing SAED approach only reacts with permanent annihilation.
Within the creation of a unique situation that economic growth, raising the standard of living and fight against poverty do not damage nature but create positive impacts on the environment: The harvest and use of Typha reduces its overgrowth. Furthermore its transformation into ecological appropriate building material has positive impacts on the local and even national economy.
That kind of innovation is the "new combination of existing technologies" and its "implementation in a new geographic area". Additionally it will take care for social acceptance and commercial structures for the future. This socio-economic feature makes the technical approach unique, too.

5.3 The fabrication of Typha as insulation material

Typha has superb insulation material. It's properties equals chemical components. Rolf-p. Owsianowski has designed a process where leaves of Typha are put lengthwise in a prefabricated box and sprayed by a gluey component. The box is situated on a conveyer belt which moves forwards. Layer after layer of dry Typha-leaves are put into the box and sprayed till a height of 2 meters is reached. A block of two meters height is pressed to a height of 1 meter. The width of the box is 1 meter, it's length is 1 meter too. The result is therefore a block with the dimensions of 1 x1 meter and a length of 2 Meters. Before the drying process has finished completely, plywood is put over and under the block and sealed with it. The block then can be transported to any location and treated there. It can be sliced however at the spot in any dimension of thickness, depending on it's further application. For insulation applications it should have 10 cm thickness at the most. In Germany Mr. Theurkorn has a considerable knowledge and experience with that matter [22]

5.4 Sustainability

By a constant supplying the populations with a new building material based on Typha, the project contributes to a sustainable management of the extending Typha occurrence along the Senegal river. The positive asset of Typha is demonstrated by the construction of affordable high-quality living spaces.
A long-lasting experience in the service sector, intensive cooperation with the government and the existing local infrastructure with experimental grounds in Ross Bethio, an experimental site of PERACOD, ensure an efficient and long-term transfer of skills to local management bodies and producers.
The major challenge is to reach the change in values concerning the acceptance of Typha as an asset of the region. The participative approach from GTZ-PERACOD combines partners like SAED and local Non government organisations as the directly concerned local women organisation, includes training, impact assessment and the development of a locally and ecologically integrated system of commercialisation in cooperation with local producers and professionally qualified experts.

5.5 Replicability and Prospects

Replicability and Prospects for Scaling up: The use of Typha for commercial purposes concerns all regions of its occurrences, especially the neighbouring countries of the Senegal river Mali, Mauritania and Senegal.
This multilateral interest group, since 1972 institutionalized by the OMVS (Organisation for Senegal river upgrading) provides an efficient platform to integrate the new Typha building material and the projects methodical approach in West Africa easily.

Furthermore the CILSS (Permanent Intersate Comitee for Draught Control in the Sahel) and PREDAS takes care for the technological transfer in the sahelian region.
The worldwide occurrences of Typha encourage the projects replicability to an international extent. Furthermore our methodical approach can be adapted for different specific conditions.
The project is to be scaled up gradually. We aim to enlarge the production of Typha building materials for the local demand into a new competitive branch of industry. This includes efforts to develop prefabricated building components which offer new solutions of low cost housing in a sustainable context.

5.6 Implementation in Senegal

In total the implementation will last five years, split in two phases, which are the three years lasting overall coordination of all concerned partners and the specific creation of a sound management body and the second phase the construction of tools, machines etc. and the erection of houses and installation of any appropriate kind.

5.6.1 Phase A, Raising and structuring the considerable existing knowledge:

A.1: Physical and chemical qualities of Typha, existing products and proceedings
A.2: Sustainable management of Typha (cutting techniques, appropriate amount of taking and its effects on biodiversity)
A.3: Transfer of knowledge concerning comparable plants already used as building materials to the specific topic of Typha

5.6.1 Phase B, Development of Typha building material(s):

B.1: Creating a spectrum of feasible Typha building materials in 1:1 samples
B.2: Evaluation of: a) simple handling in production and use, b) low costs and c) chance of acceptance in the cultural context
B.3: Selection of most promising product(s) for further application

5.6.1 Phase C, Integration of products in public consciousness and local economy:

C.1: Construction of a sample building proving technical feasibility, availability and positive image forming
C.2: (simultaneously) Finding potential reliable and local producer(s)
C.3: Handing-over of know-how and process.

6 OUTCOMES AND RESULTS

A: Structured assemblage of existing, transferable knowledge concerning Typha and comparable materials as a basis for the specific approach.
B: Spectrum of 1:1-produced Typha materials on the basis of locally gained biomass. Record of manufacturing processes and assessment.
C: Realized building with maximal content of Typha products used for construction. Products delivered by local producers. Construction of building with local workers.
>> Methodical approach is pyramidal: it starts from a broad basis of promising hypothesis' and focuses direction by continuous assessment of single results.
>> Being structured and disseminated the gained know-how enables any other group to start at the same level.
>> Self-monitoring will concern time schedule and achievement of aimed results
>> Impact on ecology will be the sustainable utilization of Typha, the production of "clean" building materials and the reduction of energy consumption by buildings
>> The local production will have positive impacts on economic growth

7 PROJECT COSTS FOR SENEGAL (fig. 4).

Expenses	Amount (€)
1. Personnel	800.000
2. Materials and Equipment	144.000
3. Training	173.000
4. Travel	050.000
5. Evaluation/Information Dissemination	050. 000
6. General Administration	155. 000
7. Other Expenses	-
8. TOTAL EXPENSES	1.372.000
9. Other Funding Sources	160.000
10. Total DM Funding Requested	1.532.000
11. Estimated Project Revenues	Factor 10 within a 10 years period

Figure 4: Table of foreseen project costs

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