# Rescuing the Flood-ravaged River Island of Majuli, Assam

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***Rettung für die hochwassergefährdete Flussinsel Majuli, Assam***

*Majuli ist eine der größten Binnengewässer-Inseln der Welt. Sie gehört zum gewaltigen, dynamischen Fluss-System des Brahmaputra-Beckens im Distrikt Jorhat im indischen Bundesstaat Assam. Die Insel liegt zwischen der Einmündung des Kherkatia-Suti im Osten und dem Abzweig des Flusses Subansari im Westen. Die fluvialen Prozesse, denen die Insel ihre Entstehung verdankt, bewirken heute ihr beständiges Schrumpfen, obwohl jedes Jahr enorme Anstrengungen unternommen werden, den Brahmaputra zu bändigen. Falls sich der Schrumpfungsprozess ungehindert fortsetzt, wird die Insel wohl in den nächsten 15 bis 20 Jahren verloren sein. Majuli ist jedoch das Zentrum der vom Vishnuismus des 15. Jahrhunderts geprägten Kultur Assams, zugleich ist die Insel für die regionale Biodiversität von größter Bedeutung.*

*Der Aufsatz beleuchtet anhand von statistischen Daten die kritische Situation der Insel. Er zeigt die Ursachen der Hochwasser und die Probleme, die aus den gehäuften Überflutungen und den daraus folgenden Erosionen resultieren. Die bisher angewandten Hochwasserschutz-Maßnahmen werden vorgestellt und hinsichtlich ihrer Auswirkungen auf den ökologischen Zustand und die Biodiversität der Insel kritisch hinterfragt. Die gegenwärtig verfolgten Konzepte sehen die Kartierung bestimmter Gebiete vor, in denen Hochwasserschutz-Maßnahmen realisiert werden sollen. Vor diesem Hintergrund wird im Folgenden ein Ausblick auf die Zukunft der Insel versucht und ein alternativer Lösungsansatz vorgestellt: Er setzt auf den Einsatz nicht-baulicher Methoden, um die Insel weniger schadensanfällig bei Überschwemmungen zu machen und gleichzeitig die Auswirkungen der Maßnahmen auf die Fluss-Ökologie und die Biodiversität zu minimieren.*

## Introduction

Floods are recurrent global natural phenomena and can have consequences on the social and economic structure, on a local or regional scale. At Majuli Island every year people and animals are swept away, houses are razed to the ground, 80 % of the land is submerged, and villages are destroyed; all due to the dual fury of flood and flood-induced erosion. Majuli is a major biodiversity hot spot of the region and the hub of Assam's 15th century Vaishnavite cultural identity.

Per census of 2011 out of the 160,000 inhabitants of Majuli about 70 % belong to tribal communities such as Mishing, Deuri, Kachari, and Koch-Rajbongsi. There are 30 Sattras (Vaishnavite monasteries) in Majuli. Each Sattra represents, within its region, a centre for cultural activities, and even acts as a democratic institution to settle local disputes. Most of the villages associate with a respective Sattra, and the villagers participate in the activities of their own Sattra during festivals and events.

Considering its cultural heritage and unique landscape, the government of India has nominated the island of Majuli for enlistment as UNESCO World Heritage site, in the Cultural Landscape category.

## Location and Physiography

The Island of Majuli is separated from the mainland of Assam by 2.5 kilometres. It is only accessible by ferry from Nimati Ghat in the Jorhat District of Assam in India. It extends for a length of about 80 km in East-West and a width of about 10 to 15 km in North-South direction. It is formed by the Brahmaputra River in the South and South West, the Kherkatia-Suti, a branch of the Brahmaputra in the North East, joined by the outfall of the Subansiri River and its tributaries in the North and North West (Fig. 1). These tributaries usually bring tearing floods with a heavy load of fine silt and clayey sediments. They have very steep slopes, shallow braided shifting channels and sandy beds. Another significant feature is the formation of islets resulting from the braided nature of the river around the Majuli Island, locally called the *chaporis*. On the island there are small ponds and oxbow lake formations with typical wetland character locally known as *beels*. These are extremely rich in flora and fauna and serve as a breeding place for many unique species. The river, its tributaries, the beels and the chaporis, along with the Island of Majuli, constitute one of the largest mid-river delta systems in the world.

## Crisis Faced by the River Island

Today, Majuli faces the dual fury of flood and bank erosion. Floods occur more than once a year. Recurring floods have been affecting the ecological balance, physical landscape,

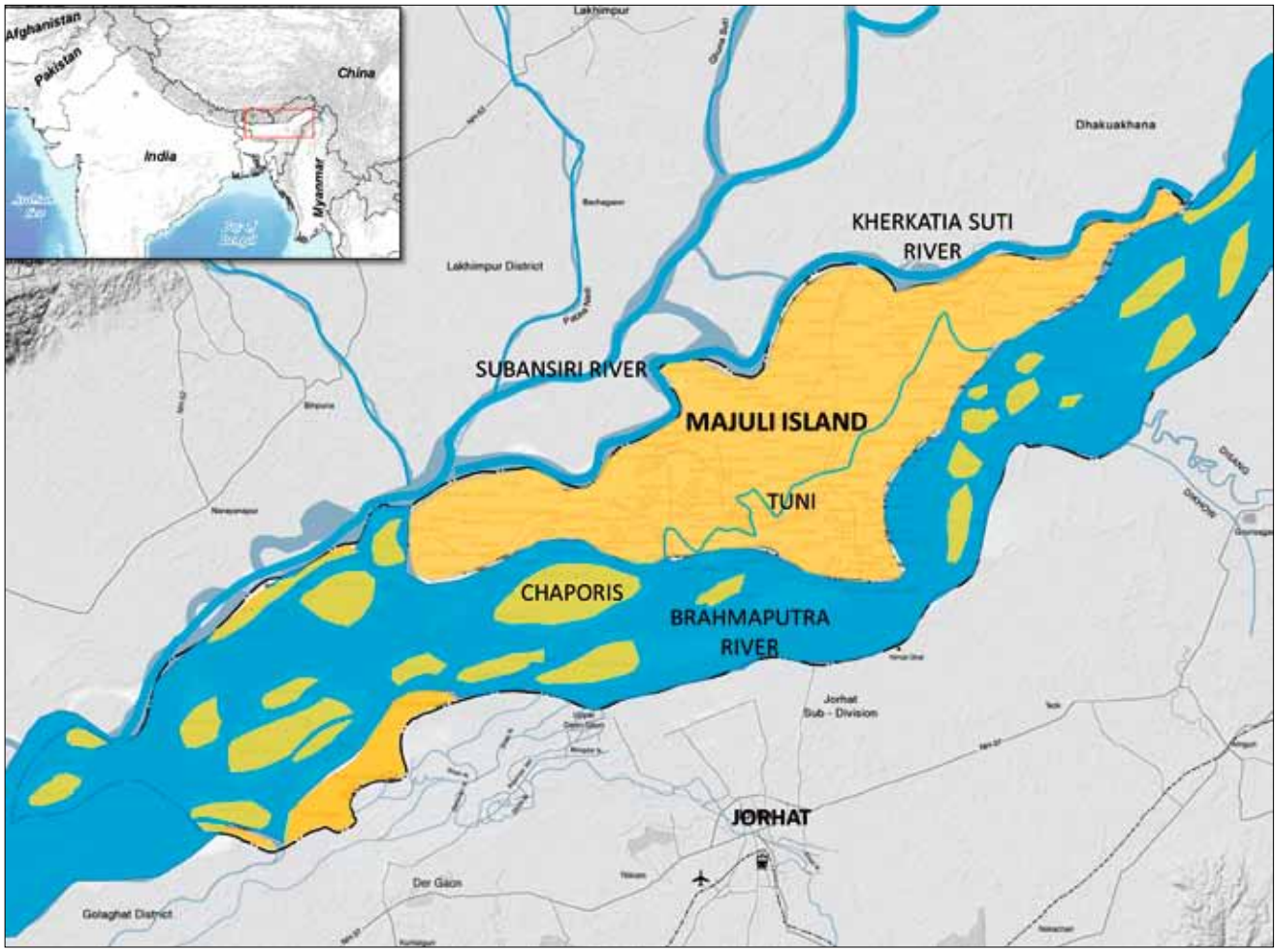
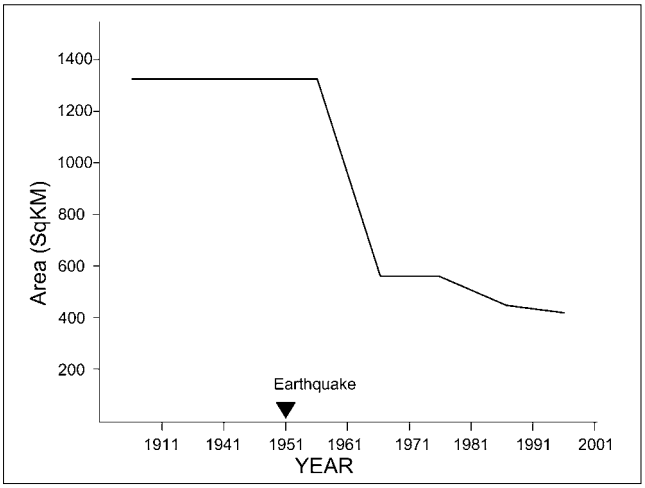



*Fig. 1: Location of the River Island of Majuli, Assam (India)*

as well as biodiversity in Majuli. The flood causes havoc amongst people and their livestock living on the island. The continuous erosion rips off the geographical area gradually (Fig. 2). The river island is receding every year: Of an area of 1345 sq km in 1891, no more than 640 sq km of land was left in 2008 (Fig. 3).[1] Since 1991 out of 244 villages, 35 have been razed by the river. Studies indicate that if this process goes on, the island will disappear in the next 15–20 years. Uncontrolled and indiscriminate development along with ineffective flood control measures for the island have led to ever-increasing flood damages in spite of the millions of money invested in the flood management sector during

*Fig. 2: Continuous erosion of the Majuli Island*

*Fig. 3: Shrinking of the Majuli island from 1911–2001*



the last decades (Fig. 4). The density of population on the island in 1901 was 24 persons per sq km, which went up to 146 persons in 1991. As per 2001 the density of population is 364 persons per sq km in Majuli. This figure is higher than the 340 persons per sq km in the whole state of Assam. The decreasing total geographical area coupled with increasing population is creating economic instability and ecological imbalance on the historic island. The flooding, which causes loss of lives and damage to property, creates a sense of insecurity in the minds of the people.

## Reasons for Flooding and Erosion

The Brahmaputra River is one of the world's largest river systems. It flows through China (50.5 %), India (33.6 %), Bhutan (7.8 %) and Bangladesh (8.1 %) for a total distance of 2880 km. With an average width of 8 km, it occupies about one tenth of its 50–80 km-wide valley.[2]

The reasons for the flooding and erosion are a combination of several natural and anthropogenic factors. The unique geographic setting of the region, high potent monsoon rainfall regime, easily erodible geological formations of the island and in the upper catchments, high seismic activity, siltation, rapid channel aggradation, massive deforestation, explosive population growth especially in the flood-prone belt, and unplanned types of temporary measures of flood control are some of the dominant factors causing or intensifying floods in Majuli.

## Natural Factors

The flooding of Majuli Island is largely due to an extreme monsoon regime in Assam and the surrounding states of Arunachal Pradesh and Nagaland, the melting of snow in Tibet and other upper reaches of the Brahmaputra River. The rainfall water discharged from upstream states along with the high rainfall ranging from 248 cm to 635 cm (from May until October) in and around the island contributes to an excessive volume of water. This large volume of water spills on to the island as it lies in the flood plain of the river. The reason for the excessive spillage is not only the large water volume but also the high silt deposition from upstream catchment areas in the river basin. Majuli lies in the middle course of the river, wherein the river gradually loses its gradient and has a sudden reduction in slope as it enters a relatively plain and flat terrain. The problem of siltation has been further aggravated due to landslides caused by high rainfall and anthropogenic factors like deforestation and shifting cultivation in the upstream regions. The silt that is brought down from the upstream areas is deposited as the river descends into the plains with sudden reduction in slope, with the consequent reduction in the flow velocity and its sediment-carrying capacity. Due to heavy deposition of

*Fig. 4: Ineffective measure, river bank after the floods (2014)*

silt and the tendency for lateral shift, the river has frequently changed its course. It has been recorded that during the late 17th century, the Brahmaputra River used to be on the northern side of the island. [3]

Bank erosion at the Majuli Island is mainly due to the instability of the river. Excessive sediment load has also given rise to a braiding and meandering pattern in the alignment of the river system, thereby increasing the spilling of floodwater over the banks. It has been noticed that bank erosion occurs during the receding stage of the floods when excess sediments are deposited as sand bars, with the channel causing the change of flow direction.[4]

Furthermore, this region lies in the high seismic activity zone of the Eurasian and Indian tectonic plates, due to which the river tends to change its course frequently. During a massive 8.7 magnitude earthquake in 1950, the river changed its course and there was a general rise of the water level by three metres, further aggravating the floods in the Majuli Island. Prior to 1950, the Brahmaputra River rarely exceeded the danger level, but since 1954, the river goes above danger mark every year more than once.

## Man-made Interventions and Their Impacts

*Institutional Responsibility for the Brahmaputra in India*

The Government of India set up an autonomous body called Brahmaputra Board under The Brahmaputra Board Act, 1980 (Ministry of Water Resources). The main task entrusted on Brahmaputra Board is the planning and integrated implementation of measures for the control of floods and bank erosion in the Brahmaputra Valley. The board mainly carries out surveys and investigations and prepares the master plan for the control of floods and bank erosion in the Brahmaputra Valley.

The Brahmaputra Board had prepared a master plan for the development of Majuli Island which included measures

*Fig. 5: Road as embankments (2014)*

for flood control, erosion control and drainage improvement. This master plan was approved by the Government of India in February 2004. The scheme titled "Protection of Majuli Island from flood and erosion", at an estimated cost of 1160 million Indian Rupees envisaged the following works to be executed in three phases, of which the third phase is on the verge of completion. Some of the earlier works have proved to be less effective in saving the island from the floods. Yet the Brahmaputra Board is continuously trying to research and implement new techniques in order to reduce the damages caused every year.

*Construction of Flood Control Dykes and Embankments*

Initially, dykes and embankments were considered immediate interventions to handle the inundation of the island. To contain the floods after the great earthquake of 1950, short term ad hoc-types of flood protection measures were taken as the construction of embankments in the form of roads (Fig. 5) were introduced in 1952–53. Embankments and dykes were constructed on the island with the limited information contained in the hydrological data and the topographical surveys available at that time. These embankments breached on a number of occasions. A total of 155 km of embankments were constructed; however, at present only approximately 90 km of embankments exist.[5]

Many embankments constructed lately have also failed to serve the purpose. The silt which used to be deposited on the floodplains of Majuli now has no spill over space because of the embankments which act as a barrier to avoid letting the silt spread on to the island. The silt thus drops back into the river channels after hitting the embankments, which leads to further aggradations. The land drainage pattern has also changed drastically because all streams are now guarded by marginal embankments resulting in high flood level within the embanked area during heavy rainfall. In some areas the sluices provided for water outlet become non-operational, leading to drainage congestion and water logging in the surrounding areas.

*Construction of Stone Spurs*

Every year, stone spurs encased in wires are constructed jutting out towards the river. These are constructed in order to curtail the force with which its waters hit the island and also to divert its flow to some extent. But some of the spurs were designed without keeping in mind the detrimental impact they could have. The construction of stone spurs in the Southern mainland side of Majuli at Hatisal, Nimatighat and Kakilamukh diverted the flow of Brahmaputra towards the lower part of Majuli and accelerated devastation in Ahatguri Mouza. The construction of these stone spurs as flood control and anti-erosional measure on the southern bank of the Brahmaputra River near the mainland is responsible for creating a number of chaporis (sand bars) and new river channels in the Brahmaputra River. These stone spurs diverted the strong current of the mighty river Brahmaputra towards lower Majuli, which was the crucial cause for the disappearance of the Ahatguri Mouza, a part of Majuli, by erosion. This example further corroborates the fact that man-made factors accelerated the environmental degradation as well as the flood-induced erosion of Majuli (Fig. 6).

*RCC Porcupines*

These are permeable prismatic structures composed of six members each, made of reinforced concrete (RCC) and joined with iron nuts and bolts. They act as dampers and are a cost-effective alternative to bank protection works for the Brahmaputra River, which carry a considerable amount of silt. Being permeable structures, RCC Porcupines can be used either independently or with the support of impermeable boulder structures or river training and bank protection measures. Depending on the purpose, they can be placed transverse or parallel to the direction of flow.

They are designed for a partial obstruction of about 15 to 20 % to the flow of the river. Higher obstruction causes more diversion of flow resulting in undesired scouring around the proposed structures, particularly at the nose portion. Additional protection to the nose and flanks is required to avoid such scour (Fig. 7).

Permeable structures in the form of RCC Porcupines are envisaged for training the river along the desired course, reducing the intensity of flow at the point of river impact and providing protection to the bank by damping the velocity of flow along the bank.

RCC Porcupines have been found quite effective in reducing the intensity of erosion of the river Brahmaputra at Majuli Island by providing protection to the banks, as the Porcupines damp the velocity of flow along the bank. They are cheap in cost (one third the cost of a revetment), easy to construct, sustainable and without significant adverse ef-

*Fig. 6: Stone Spur before & after the floods of 2013*

fects upstream or downstream or on the opposite bank. In the case of high velocity flows, the implementation of RCC Porcupine works only is not favoured as they then prove to be ineffective. But in general, in areas where partial siltation has taken place, additional Porcupines are placed in the second year to make the silted region firmer.

*Deforestation and Encroachment*

Human intervention and destruction/construction not just in the affected area but also in the watersheds aggravate the problem. Deforestation around the Majuli area and its watershed has led to an accelerated rate of soil erosion, resulting in gully erosion and loss of soil fertility on the one hand and in severe floods and erosion on the other hand. The increasing population and decreasing land is a major problem in Majuli, leading to the encroachment of a large number of wetlands which serve as natural reservoirs, such as beels, swamps and marshes for both agricultural as well as habitation purposes. This has further reduced the retention capacity of the drainage system, causing the level of floods to rise.

Each year hundreds of people have to be displaced around the river banks during the floods. Some people stay until the very last moment of flood, hoping that nothing adverse will happen. This leads to the loss of property and many lives.

Construction activities also pose a threat to the Brahmaputra River Valley. There has been a lot of hue and cry to oppose any large constructions all along the river valley throughout India and Bangladesh. Dams are being built on the upper middle course of the Brahmaputra River, which is situated in the Chinese territory of Tibet. The Zangmu Dam,

*Fig. 7: R.C.C. Porcupines before & after the floods of 2013*

| TECHNIQUE | RELATIVE BUDGET | EFFICACY | REMARKS |
|---|---|---|---|
| **EMBANKMENTS** | HIGH |  POOR | • The embankments that were built around 1950's by the government agency had negative impact too. The embanked areas were flooded within and this further led to siltation of the river valley. |
| **SPURS** | HIGH |  AVERAGE | • River water is diverted, eroding the land which comes in the way to the speedy flowing river |
| **R.C.C. PORCUPINES** | LOW |  AVERAGE | • R.C.C. porcupines are the low cost to increase the siltation<br>• Have a requirement of installation in layering and reapplication after certain time |

*Fig. 8: Comparison of various flood control techniques employed for flood and erosion control*

operative since 2014, is one of them. It is feared that these dams might have an enormous impact on the ecology, ecosystem, seismicity, and society along the river valley. Furthermore, it is difficult to predict how the river might behave with such interventions along its course.

## Future Human Intervention

Man has modified the landscape of Majuli for years in many ways and any modification is likely to cause changes in the drainage system of the river valley, including the floodplains. Human intervention in the landscape of Majuli has mostly hastened the process of flood-induced erosion.

The attempt made by the government agencies to save the island from flood and flood-induced erosion was well-intentioned, but initial lack of information, insufficient analysis of the site situation and lack of up-to-date techniques had a detrimental impact on the river island's condition. Some of these structural changes have had severe consequences on the flooding pattern of the region and have actually escalated the flooding in and around it (Fig. 8).

The embankments built around the 1950s by the government agency had a negative impact as they were adopted as an alternative to a long-term holistic solution for the Brahmaputra Valley. The embanked areas were flooded within and this led to further siltation of the river valley. Other engineered solutions of stone boulder spurs have proved to be hazardous for the areas where the river water is diverted to, in turn eroding the land which is in the way of the hastily flowing river.

RCC Porcupines have proved to be a low-cost method to increase siltation on the island but have certain drawbacks of their own, such as the requirement of installation in layering and of reapplication after a certain time.

These man-made elements have altered the drainage pattern of the island and have had a deleterious impact on the regime of the river, causing aggradations, enhanced flood condition and river bank erosion on Majuli Island. All this is not only leading to shrinking the island to its extinction, but it is also largely impacting the physical landscape and human ecology of the river island of Majuli and the whole Brahmaputra Valley.

To avoid a higher occurrence of flooding, landscape modifications should be given careful consideration. The development on the floodplains of the regions in and around Majuli should therefore be undertaken with great care.

Hence, judicious application of engineered solutions and environmentally friendly methods coupled with regulatory (non-structural) approaches to reduce the vulnerability of the river island towards flood and flood-induced erosion are required.

Some of the alternate sustainable and eco-friendly methods requiring fewer finances can be:

– Tubular sand-filled mattresses for bank protection pitched along the river banks. This can help to reduce the erosion.
– Vetiver grass (*Chrysopogon zizanioides*) can be used for reducing soil loss in the embanked areas or sloped banks. The advantage of this grass is that it can grow in any type of soil and is able to withstand heavy rainfall. Planting vetiver can help to stabilise the slopes, thus preventing erosion. It can also be planted in combination with other methods like planting them over the sand-filled jute bags.
– Using geo fabric for the construction of Geo-Tube dykes to enhance the stability and tensile strength of the banks. This can also help to reduce the force with which the gushing flood waters enter the island.

## Regulatory Approaches to Reduce Vulnerability

With a better understanding of the behaviour of rivers, the probability of flooding, and of areas likely to be flooded, measures can be undertaken to reduce the vulnerability to flooding and flood-induced erosion.

Some of the non-structural measures that can be easily employed for Majuli are:

– Annual scientific collection of flood damage data like velocity, depth of flow before and after floods, etc at various critical zones. These data can be used as basis for wise preparations of flood risk maps;
– River morphological studies through satellite imagery for the study of bank migration in order to gauge in advance the areas likely to come under threat of erosion;
– Further augmentation of the flood forecasting and flood warning network, particularly for the tributaries flowing down from the upstream regions of Bhutan and Tibet (China), under the umbrella of this network;
– Preparing a watershed management plan for hilly upstream catchments of northern tributaries, which will impact the downstream regions of Majuli directly;
– Floodplain zoning which will restrict construction on and habitation of areas closest and most vulnerable to flooding; instead using these areas for agriculture, recreation, or other uses that won't endanger lives and property;
– Preparation of a disaster management plan and awareness programme to minimise losses during the flood.

## Conclusion

Although we have been trying to do our best to save the river island of Majuli, we have somehow failed to control the situation after the 1950s. The Brahmaputra River basin has become ecologically imbalanced because of sedimentation due to accelerated soil erosion, which has been caused by human-made factors. Random construction of embankments has mainly worsened the problem of flood inundation. Further, deforestation, encroachment on natural reservoirs, marshes and swamps have reduced the retention capacity of the drainage system, causing the level of floods to rise.

It is up to us to either accept the situation by letting the region face its extinction or have an interdisciplinary approach to combat the flooding situation and erosion. It is important to have a broad vision for the future of the island and an approach that includes structural, sustainable and non-structural measures to solve the problem of flooding and flood-induced erosion. We need to be very careful in what we try, because a minor mistake can unbalance the whole ecosystem of the region. It is crucial for us to remember that humans are subservient to nature. In order to co-exist with nature we must build harmoniously in order to safeguard the future of the river island of Majuli.

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[1] See NATH, Human-Induced, 2012, p.17.

[2] SARMA, Rural Risk, 2013, p. 11.

[3] See BHASKAR, et al., 2010, p. 2.

[4] KHARYA, et al., RCC Porcupines, 2012, p. 2.

[5] KHARYA, et al., RCC Porcupines, 2012, p. 2.