

## Understanding the differing realities experienced by stakeholders impacted by the Agats municipal water supply, Papua

E.V. Wambrauw<sup>1\*</sup> and T.K.K.B. Morgan<sup>2</sup>

<sup>1</sup> University of Auckland, Auckland, New Zealand  
& Cenderawasih University, Jayapura, Papua, Indonesia,  
e-mail: ewam002@aucklanduni.ac.nz

<sup>2</sup> University of Auckland, Auckland, New Zealand,  
e-mail: mamadou.sissoko@somapep.ml

**Abstract:** Agats Township is the capital of the Asmat Regency in southern Papua, Indonesia. The tidal range normally inundates the urban area, and fresh water supply is a problem for residential occupancy. Climate change has exacerbated this problem with an increasing extent of inundation and sediment deposition. A solution implemented to address the water supply requirements for Agats has introduced inequalities for the regional community. Issues beyond equitable access to the water supply such as cultural transgressions raise further questions regarding sustainability. An earlier study showed that some aspects of Asmat Culture resonate with the Māori of Aotearoa New Zealand. The research identified as feasible the transfer of an assessment framework which was created specifically for the New Zealand context to Asmat. The Mauri Model Decision Making Framework (MMDMF) is a unique sustainability assessment framework for gaining insight into complex problems. The objective of this research is to apply the MMDMF in Asmat to measure the sustainability of a Local Government project to supply fresh water to Agats Township. The Mauri Model evaluation shows that the project is not sustainable from the Asmat People's perspective, but it is considered sustainable by the Local Government. The Mauri Model shows that benefits are accrued in the social and cultural dimensions, while the environmental and economic dimensions are diminished. The differences in worldview values and therefore the perception of an infrastructure project's sustainability stem from the different values of the stakeholders effected. The findings demonstrate the international applicability of the Mauri Model Decision Making Framework in other cultural contexts.

**Key words:** Asmat, Māori, water management, Mauri Model, mauriOmeter.

### 1. INTRODUCTION

River Basin Management is one of the most complex and rapidly changing contexts of Resource Management today (Molle, 2009, Shmueli, 1999). The combining impacts of historic land management, river basin modification and climate change associated sea level rise and storm event ferocity are creating engineering challenges that have not been previously recorded. Understanding the wider implications of infrastructure developments in river basins must then be an essential area of further investigation as these engineering interventions add to the complexity being created. This article shares a unique new evaluation framework that unravels this complexity and provides a means of integrating the myriad interconnected facets of knowledge required to understand the problem. Agats Township located in the Asuwetz River Delta (Asmat Regency) of Papua. The results are then portrayed as they are perceived by stakeholders holding opposing views illustrating the influence of worldview bias in engineering decision making.

Agats Township is the capital of the Asmat Regency in southwestern lowland Papua Indonesia. Asmat is the largest tidal lowlands area of Papua and one of the largest alluvial swamplands in the world (Kar, 2013) having the attributes of a globally unique ecosystem (Mawdsley and Houterman, 2010) because it stretches from coastal Arafura sea to about 200 Km inland to reach the first mountainside (Tommaseo and Lucchetti, 1992, Paoletti, 1995) and with significant cultural diversity (Giesen and Houterman, 2009).

One of the UNESCO World Heritage Parks, the Lorentz National Park (Davidson, 1990, Asmat

Government, 2011b, Asmat Government, 2012b) which is the largest protected area in Southeast Asia, is also located in this area together with other regencies (Papua-Government, 2013). The park is also the only “continuous transect from snow cap to tropical marine environment (Hawkins, 2004). The tidal range of Asmat affects the delta up to 140 km inland from the ocean with a 25 km to 50 km wide mangrove zone (Giesen and Houterman, 2009, Mawdsley and Houterman, 2010) and a wetland that covers 80 % of the total area (Asmat Government, 2011b). A minimum of 50 cm water height inundates this area at least three months in a year. A mixed swampy forest of Nipa and Sago Palms dominates the riparian margins in this area. The vegetation covers shallow to deep peat land, intersected by many rivers and streams (Paoletti, 1995, Simon, 1977, Smidt, 2013), creating the unique biophysical attributes of Asmat.

The vast fluvial plain consists more than one hundred waterways and several big rivers of over one hundred kilometers in length (BPS Asmat, 2013). The indigenous people of this muddy area are the Asmat People who are inseparable from water and rivers, as each clan lives around the river basins (Konrad et al., 2002) which influence their culture and life style, such that a canoe is a daily part of their life, and using the river waterways to manage the border of the “*dusun*” (the ancestral domain of the Asmat People and it can be a forest which provide food, wood, etc.) (Daeli, 2012). They also build their house on stilts or trees (Tommaseo and Lucchetti, 1992).

The Asmat People have a culture of sustaining the balance in the universe; they believe in a consistency between human beings, the environment and the spirit of the environment (Schneebaum, 1990, Schneebaum, 2000, Schneebaum, 1988, Jimanipits, 2012, Koentjaraningrat, 1989, Konrad, 1981, Konrad et al., 2002, Goldbarth, 2006, Mansoben, 1995). Infrastructure development in Asmat is expected to proceed rapidly resulting in a population of 22.04 % in Agats District due to immigration between infrastructure development in Asmat is expected to proceed rapidly between 2005 to 2011 (BPS Asmat, 2012). As a consequence, the increase in population, the demand on natural resources and water has increased, especially Agats Township.

Agats Township is a part of Agats District which is located along coastal area of the Arafura Sea in The Flamingo Bay and along the Asuwetz River Delta (Figure 1).



Figure 1 Satellite image of the Agats Township (Asmat Government, 2012)

According to the Asmat Master Plan (Asmat Government, 2011a, Asmat Government, 2012b), tidal swamps in this region are divided to 4 zones; zone 1 (permanently inundated by water and influenced by high tide), zone 2 (seasonally inundated by water), zone 3 (the area used to be inundated), and zone 4 (no influence from tide). Agats Township is located in zone 1, so it is covered by water during tide rise, especially the areas along the rivers which below the sea level.

The tide rise approximately 3 to 4 meter above sea level (Latief, 2005) and according to information even up to 5 meter above sea level (AgatsBishop, 2014, Indonesian Government et al., 2011, Bigourdan, 2006) and 1.5 meter above ground level (AgatsBishop, 2014). Thus, this township also known as the muddy town, is an exotic place with no land to stand on and all roads are constructed using elevated wooden structures (Lubis, 2012). All construction is at least one or two meters above ground level. All houses, roads, fields, and schools are made from timber, giving the town a distinctive character (Figure 2).



Figure 2 Agats Township (Wambrauw, 2012)

Recently a composite concrete bridge was built in this tidal zone, replacing several wooden bridges, showing how new ideas and methods of construction are arriving in the area. The only land transport is electric motor bikes and bicycles. The tidal range normally covers this area, and getting fresh water is a problem for residential occupancy. People cannot use surface water or ground water due to its brackish tasting character and, due to a lack of waste management for the area; it is polluted by solid waste and sewage.

A scoping survey (2012) established that the Asmat People used to take water from rivers or swamps for domestic purpose; however, the spread of water pollution has made these resources inappropriate. Now, people depend primarily on rainwater from roof catchments which is supplemented by bottled water which is relatively expensive due to the difficulties associated with transportation. The Asmat People also maintain traditional practices that involve paddling canoes into the Nippa or Sago forest, called *dusun* sago, to collect fresh water from under the root systems.

Recently, assessments have developed around the world to assist decision making regarding the equitable distribution of benefits associated with infrastructure development. Societies face complex problems if only considering economic, technical, and environmental issues without considering the social-cultural context. Socially just decision making has developed around the world such as; in the UK where it is associated with climate policy (Bell and Rowe, 2012); and in urban planning in Portugal (Cardoso and Breda-Vázquez, 2009). The decision making approaches developed for complex socio-cultural contexts may be suitable for Papua which is rich in cultural diversity with more than 375 ethnic groups (Wambrauw, 2013) and more than 250 local languages (Mansoben, 2006).

An approach that includes cultural aspects is the Mauri Model Decision Making Framework (MMDMF) which is a unique sustainability decision making model that was developed in New Zealand (Morgan, 2006a). It has been used to assess some engineering contexts such as in water and environmental issues (Fa'au and Morgan, 2014, Morgan, 2006a, Morgan, 2004, Morgan, 2006b, Morgan et al., 2012).

This paper will apply the Mauri Model Decision Making Framework in Asmat, Papua, to evaluate the water supply infrastructure decision making for the Agats Township.

## 2. ISSUES WITH THE LOCAL GOVERNMENT WATER INFRASTRUCTURE PROJECT IMPLEMENTATION

The Papuan Government plans to improve the services of water supply in Papua as part of “*Spatial Planning Infrastructure Papua Province*” (RIPI) between 2011 to 2031 (Papua Government, 2013), which are divided into seven zones including the Asmat regency as part of zone 6. In Asmat, the Local Government has developed the water supply in several areas including Agats Township (Agats District), Atjs District and Omor Village (Sawa Erma District). These districts have contributed to the Master plan of the Asmat regency, within which water issues have been considered by the Local Government at both regency and provincial levels (Asmat Government, 2011a, Asmat Government, 2012b). The Local Government of Asmat recently considered alternatives for water supply for the town of Agats. Ground water extraction practiced in Atjs District is not an option for Agats District due to salt water intrusion.

The Local Government conducted a study analysing the water quality of several big rivers (Asmat Government, 2011a) including the Asuwetz River which has 122 Km length and 450 m wide in estuary (BPS Asmat, 2013). The study concluded that there were two viable alternatives. The first was to pipe brackish water from the Asuwetz River and would require expensive treatment. The report (Asmat Government, 2012c) identified that water from the Asuwetz River would need advanced treatment due to the high level of salinity. The second was to use the nearest potable fresh water source, the Yomot River (also known as Yombot or Yomat River/Swamp/Spring), which had been investigated since 2006. The alternative to source water from the Yomot River (Figure 3) in Yepem village was considered more reasonable due to its proximity to Agats and the quality of the water available.



Figure 3 The clearing to access the Yomot River and the intake in Yomot River, Yepem Village (Asmat-Government, 2012)

Potable water supply infrastructure provision in Agats is difficult due to the combined challenges of transportation of materials, access, appropriately skilled workforce, and cost. Never-the-less, the project is proceeding. The project involves two sources of funding from the national budget (*Anggaran Pendapatan Belanja Negara / APBN*) and regional budget (*Anggaran Pendapatan Belanja Daerah / APBD*). The budgets which are allocated to the project from 2006 to 2031 can be seen in Table 1 with operating and maintenance costs estimated to be approximately IDR 400 to 500 million annually.

The water supply system has operated since 2010 with a water take of 10 litre per second (Hendrawan, authorised staff from Local Government, Personal Interview, 2012 and 2014). There are however issues with the current infrastructure solution and its implementation. These issues include; intermittent supply; availability of connections; plumb-out of housing; and inconsistent distribution of benefits from the scheme. The water is planned to operate 6 hours/day during the long-term dry season. In fact, the region has a high rainfall of 3000 to 4000 mm annually (Asmat Government, 2011c), even a previous study said the average rainfall reach 4600 mm annually (Ponzetta and Paoletti, 1997), and according to field study (Wambrauw, 2012) the local people said

at least 2 or 3 weeks once, they have a rainy day. Thus, the operation of the water service is normally every two days, and will be not flowed during the rain. The distribution system of the water supply uses a branch system which is divided into 3 zones (Figure 4) due to the capacity of water debit. Each zone will be flowed for 2 hours.

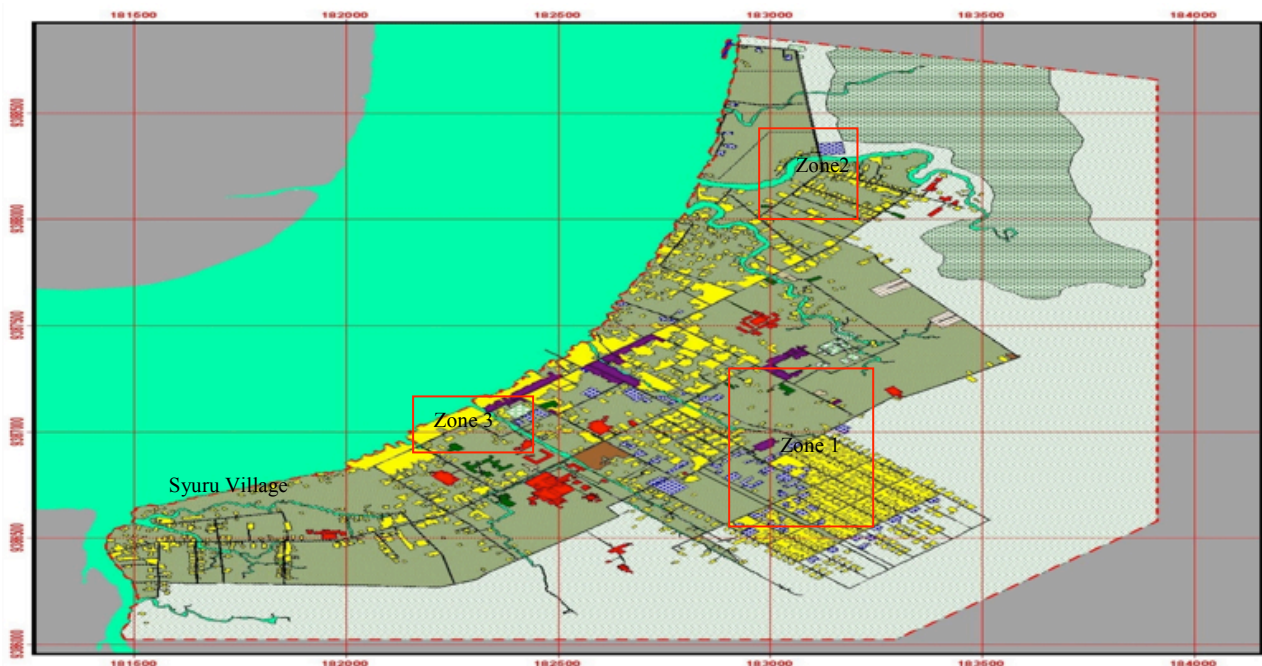


Figure 4 The three zones of the water supply service (Asmat Government, 2012)

Table 1 The Budget for the Project of Water Supply in Agats Township

No	Information	2006	2007	2008	2009	2010	2011	2012	2013	2014	2016-2020	2021-2026	2026-2031	Budget in IDR (Billion)	References
1	Planning & Infrastructure intake in Yepem Village & reservoir in Agats	x	x	x										6.1	(Daeng, 2012)
2	Infrastructure & distribution system (APBD)					x								1.1	(Hendrawan, Personal Interview, the authorized Local Government, 2012 and 2014)
3	Infrastructure & distribution system (APBD)						x							1.5	
4	Infrastructure & distribution system (APBD)							x						1.4	
5	Infrastructure & distribution system (APBD)								x					2.5	
6	Infrastructure & distribution system (APBD)									x				2.13	
7	Increase the capacity of intake to 13 l/second (APBN)									x				11.47	
8	Maintenance system (APBN)									x				5.74	(Papua Government, 2013)
9	Increase the capacity of intake to 20 l/s (APBN)										x			9.57	
10	Maintenance system intake 20l/s (APBN)											x	x	1.91	
12	Household Connection (APBN)											x	x	7.8	
13	Maintenance of Household connection in Agats (APBN)												x	1.56	

While the infrastructure has been in operation for several years, it still does not service the whole population of the township of Agats. In 2012, the water supply only serviced 25% of the Agats population as reported by Kompas, a national newspaper (Daeng, 2012). By 2014 the service level

was approaching 40% (Hendrawan, 2014). According to spatial planning of the Development Infrastructure of Papua (RIPI), the Local Government expects to service up at 50% of the population of Asmat by 2028 (Papua Government, 2013). The Local Government had installed plumbing for 560 houses by 2012 (Personal Interview, 2012) and has now increased the service to 1300 houses and 8 public hydrant in 2014 (Hendrawan, Personal Interview, 2014)

A study in 2012 identified political issues arose and the plant shut down due to unresolved land issues regarding the water source. A specific dispute involves compensation for customary land rights. A dispute showed that further negotiation between Local Government and the community was needed as inequities were evident in the project's implementation including service levels and which Agats communities connected to the water supply. These political issues reflect a lack of alignment between the project implementation and the context within which the project was being carried out. Thus, the aim of this research is to assess the holistic sustainability of the solution for water supply in Agats, when using water from the Yomot River.

### **3. METHODOLOGY**

#### ***3.1. Research Approach***

Earlier research (Morgan, 2006b) investigated the appropriateness of water treatment alternatives using the Mauri Model Decision Making Framework. The Mauri Model measures the sustainability of alternative infrastructure technologies incorporating indigenous people's perspectives. When there is alignment between the traditional values and government policy this ensures the long term sustainability of the project. However, modernization, changing power dynamics due to immigration, and gradual changes in ecosystems sometimes limit the influence of the indigenous people.

The economic and technology based approaches of engineering problem solving sometimes face insurmountable complexity in practice, when indigenous perspectives must be accommodated especially in the areas where those indigenous peoples still live. Traditional and scientific knowledge understand and describe the infrastructure solutions in different ways. The research will use the Mauri Model Decision Making Framework to assess the sustainability of the solution, and provide a deeper understanding of the complexity inherent in this challenge.

#### ***3.2 The Mauri Model Decision Making Framework***

The Mauri Model Decision Making Framework (MMDMF) is a unique sustainability assessment approach that was developed in and for Aotearoa (New Zealand). The assessment approach uses the concept of 'mauri', the binding force between spirit and substance which enables life and wellbeing. Mauri is an important element in Māori culture, a central concept that informs sustainability (Morgan, 2008).

The characteristics of the MMDMF can be seen in Table 2.

The framework has been applied to engineering case studies when assessing complex problems. The framework measures four dimensions of mauri as the basis of the sustainability assessment: the mauri of community (social), the mauri of family unit (economic), the mauri of the ecosystem (environment), and the mauri of the tribe (culture). Assessment of dimension indicators using the mauriometer, determines the sustainability of infrastructure development options.

Cawthron Report 2224 (Challenger, 2013) established that the Mauri Model is one of only three sustainability indicator sets which fully meets the eight principles of the Bellagio STAMP criteria (Pintér et al., 2012). The Cawthron Report found that the Mauri Model was the only sustainability framework that is relevant regardless of the community. This suggests the framework could be appropriate for use within contexts outside Aotearoa New Zealand.

Table 2 The Characteristics of the MMDMF (Morgan, 2008)

Characteristics	
<b>Inclusive</b>	Effective, incorporate and represent Māori perspectives
<b>Indigenous</b>	adopt a sustainability of indigenous knowledge
<b>Holistic</b>	demonstrate ecological integrity
<b>Eco-centric</b>	adopt a sustainability measure from indigenous thinking
<b>Equitable</b>	deliver intra- and inter-generational equity
<b>Legally relevant</b>	be effects focussed and promote social, economic, environmental and cultural wellbeing
<b>Integrated</b>	demonstrate interconnectedness between the criteria chosen
<b>User friendly</b>	be flexible yet easy to understand in its application), definitive (clearly determine whether a practice is or is not sustainable
<b>Transparent</b>	clearly identify applied bias

### 3.3 The feasibility of using the MMDMF in Asmat

Previous research has established that aspects of the Asmat identity (Wambrauw and Morgan, 2014) defined by their cultural values and traditions, resonate strongly with those of the Māori, the Indigenous Peoples of Aotearoa New Zealand. Both Indigenous Peoples have concepts of the environmental guardianship; *kaitiakitanga* (enhancing mauri of the ecosystem) (Morgan et al., 2012, Robert et al., 1995) and *yi-ow* (guardian of sago) of the Asmat People (Koentjaraningrat, 1989, Mansoben, 1995). Māori have *takarangi*, the concept of balance and complementarily, while *ja asamanam apcamar* is the concept of maintaining the balance of life for the Asmat. Asmat people also have a concept of land and water conservation for future generations called *jo bakat fakar* and *capinmi fakar* which parallels the belief *whatungarongaro te tangata toitū te whenua* for Māori. These parallels demonstrate reasonable alignment of thinking in relation to the environment indicating that the conceptual underpinning of the MMDMF can be substituted with Asmat ontology and epistemologies.

## 4. ANALYSIS OF STAKEHOLDER VALUE AND QUANTIFICATION OF WORLDVIEW PRIORITIES

To analyse the project, two stakeholders are chosen to represent those engaged with the project; Local Government and the Asmat People. In this case study, the worldview dimension priorities are calculated using a modified pair-wise comparison based on the Analytic Hierarchy Process (Saaty, 1980). The comparative importance between mauri dimensions ranges between -3 to +3 where the maximum score shows the most important of the mauri dimensions from the particular stakeholder's perspective.

The weighting of the priorities use assumptions based on the observation study (Wambrauw, 2012), the literature reviews, the primary data (questionnaire and interview). Table 3 shows the worldview priorities of the two stakeholders.

Table 3 The Mauri Model – Worldview Dimension Priorities

Worldviews	The Local Government	The Asmat People
The mauri of the ecosystem	14%	33%
The mauri of the tribe	17%	33%
The mauri of the community	44%	12%
The mauri of the economy	25%	22%

The results indicate that the community takes highest priority in the Local Government decision making followed by economic considerations. These two dimensions account for more than two thirds of the weighting in terms of priority. The ecosystem and cultural considerations are lower

priorities. The result is consistent with the stated priorities of the development of the infrastructure of water supply at provincial level which is focused on the community and economic purposes (Papua Government, 2013).

These priorities are reflected in the behaviour of Local Government. The Local Government always attempts to solve the water problems in Agats Township with some alternatives, even though the costs of the infrastructures are expensive due to difficulty of mobilisation material. There being no heavy vehicles so human power was used to carry everything. The distribution pipes has installed around the government offices and the houses of the staff who work for the government and the houses of the community in some areas. Some areas have been not installed because of waiting for the state budget and the lack of water debit. The Local Government have made a plan to install in area around Agats Township according to the annually allocation of the regency budget (Asmat Government, 2012a, Asmat Government, 2012b, Papua Government, 2013), this place the economic as the next consideration. In the same time, the Local Government shares the budget for the others infrastructure which are water supply in District Omor (debit 2 litre/second) and District Atjs (4 litre/second), and the construction of the concrete bridge which replacement wooden bridge. The release of the customary land right also has been paid at IDR 3 Billion (approximately 0.3 Million US dollars).

Even though the culture and the ecosystem are put the two last priorities, those dimensions are still involved in the Master Plan of the Regency which states consideration of the sustainability, balance and harmony in its development to enhance the peoples' wellbeing in their defence and security. As explained that the motto of *ja asamanam apcamar* or keep in balance influences the local policies. The Local Government also support the Cultural Festival every year and keeping some the wooden bridge town as its unique identity. For the ecosystem, the government do collaboration with WWF to restore some critical area (Mawel, 2013b).

Conversely from the Asmat people's perspective, the culture and the ecosystem are the most important priorities having high priority reflected by their two thirds combined weighting. The economic and the community considerations are lower priorities. As the indigenous people, the Asmat People are an inseparable part of nature. The Ecosystem shapes their culture and the culture respect the environment. For example, due to the primarily saturated and inundated condition of the geographic area, the Asmat people use canoe as a basic tool of life. A canoe (*ci*) is used for fishing, hunting, and gathering. If they say "*ci opak, jis opak*" it means no canoe, no firewood. They need the canoe to go to the *dusun* (forest) which provides all their needs including firewood, food, and the components for feasts (Daeli, 2012). This defines the same importance between the environment and the culture on the Asmat People's perspective. Water (*mbu*, local language) possesses cultural attributes that are essential in facilitating the growing of the child to become an adult (Personal Interview, 2012). The Yomot River location for the water supply has traditional value for its people; it is a sacred place, called Cifa Bambu.

Inevitably, the increase of the population of Agats Township affects the demand on the water resource. The people whose livelihoods are located within the Yomot River allow sharing of their water resource with the consequence that there is compensation in the form of a payment of the land right. However the way of life of the Indigenous People is changing in that they cannot depend to the same extent upon nature because they now have to compete with other outsiders in order to survive. Thus while the economic and community dimensions are still considered to be the lesser priorities, the historical underpinnings of the Asmat way of life, the Yomot River ecosystem, are under threat of significant denigration. Such denigration could lead to a change in the way of life of the Asmat People including food storage practices and diet.

## 5. HOLISTIC SUSTAINABILITY ASSESSMENT INDICATORS AND ANALYSIS

To analyse the project indicators related to impacts on the mauri for the four dimensions of the sustainability are chosen which consider the context of Asmat and Local Government. The Local Government proposed provision of a water supply infrastructure for Agats Township using water



from Yomot River (Asmat Government, 2011b, Asmat Government, 2012b, Daeng, 2012), and the construction commenced late 2006. Five year time interval are used in this analysis starting from 2006 to align with the Regency Master Plan 2011 to 2031 and the Spatial Planning of the Development Infrastructure of Papua (*Penyusunan Detail Rencana Induk Pembangunan Infrastruktur Propinsi Papua* (RIPI) 2011 to 2031) (Asmat Government, 2011b, Papua Government, 2013).

The economic indicators are the cost which is related to project construction and maintenance, and the contribution of the project to the economic sector. The community indicator are chosen to reflect the social conditions and including the happiness which is adopted from the study of Melanesian indicators (Tanguay, 2012). The ecosystem indicators are chosen to best reflect ecosystem attributes affected by the project. The cultural indicators are chosen based on the local conditions including the concept of balance, the concept of sustainability and traditional value. These indicators are listed in the Figure 5. The indicators are ranked using the mauriometer on an integer scale from -2 to +2. Scores are determined using an assessment sequence that determines the impact on mauri (zero result if no impact), as positive or negative, and partial (1) or full (2), with a positive result implying a sustainable outcome. The integer scale is deliberately coarse providing a universal measurement approach for all indicators. Indicator scores are based on research data including interviews, literature survey, field observations (2012) and the existing conditions during the research. After averaging the indicator scores within each dimension, the trends can be determined over time (5 year intervals) and plotted on two axes. The vertical axis represents the average dimension mauri score while the horizontal axis is time. The plot of mauri score over time for each dimension provides an understanding of the trajectory for that dimension and helps identify long-term trends.

The mauri against time plot also provides the opportunity to measure areas confined by either the curve or the x axis or alternatively the area confined between the curve and the initial mauri score for that dimension (or a target or policy threshold established independently). The area confined between the mauri curve and the horizontal axis ( $x = \text{zero}$ ) represents the net cumulative impact on mauri; the areas below the horizontal axis measuring negative cumulative impact; the areas above the horizontal axis measuring positive cumulative impact. This net quantification of mauri-years represents the inherent resilience change that occurs over time. The quantification of the real cumulative impact, the area confined between the curve and the horizontal line with the initial mauri dimension score is the real cumulative impact and represents the total impact accrued or conversely the total mauri-years that must be accrued over and above the initial mauri state to return the system to its original mauri state.

For this analysis the net impact upon mauri is being determined, that is the diminished resilience or conversely the enhanced capacity within any particular dimension. To simplify the calculation of these areas of the impact on mauri, the area is divided into sections as interval time (5 years), and the integration result of the linear function of the curve shows the impact area. The equations below (Eq.1 and Eq.2) are used to determine the area of the impact on mauri. The results of overall assessment of the impact upon all dimensions can be seen in the Table 3.

$$A = \sum_{n=1}^{n=5} A_n \quad (1)$$

$$A_n = \int_{x_1}^{x_2} f(x)_n \quad (2)$$

where  $A$  the total area of the impact on mauri  
 $A_n$  the area each section  
 $n$  sections  
 $f(x)_n$  the linier function of each section  
 $x_1$  the first year  
 $x_2$  the last year

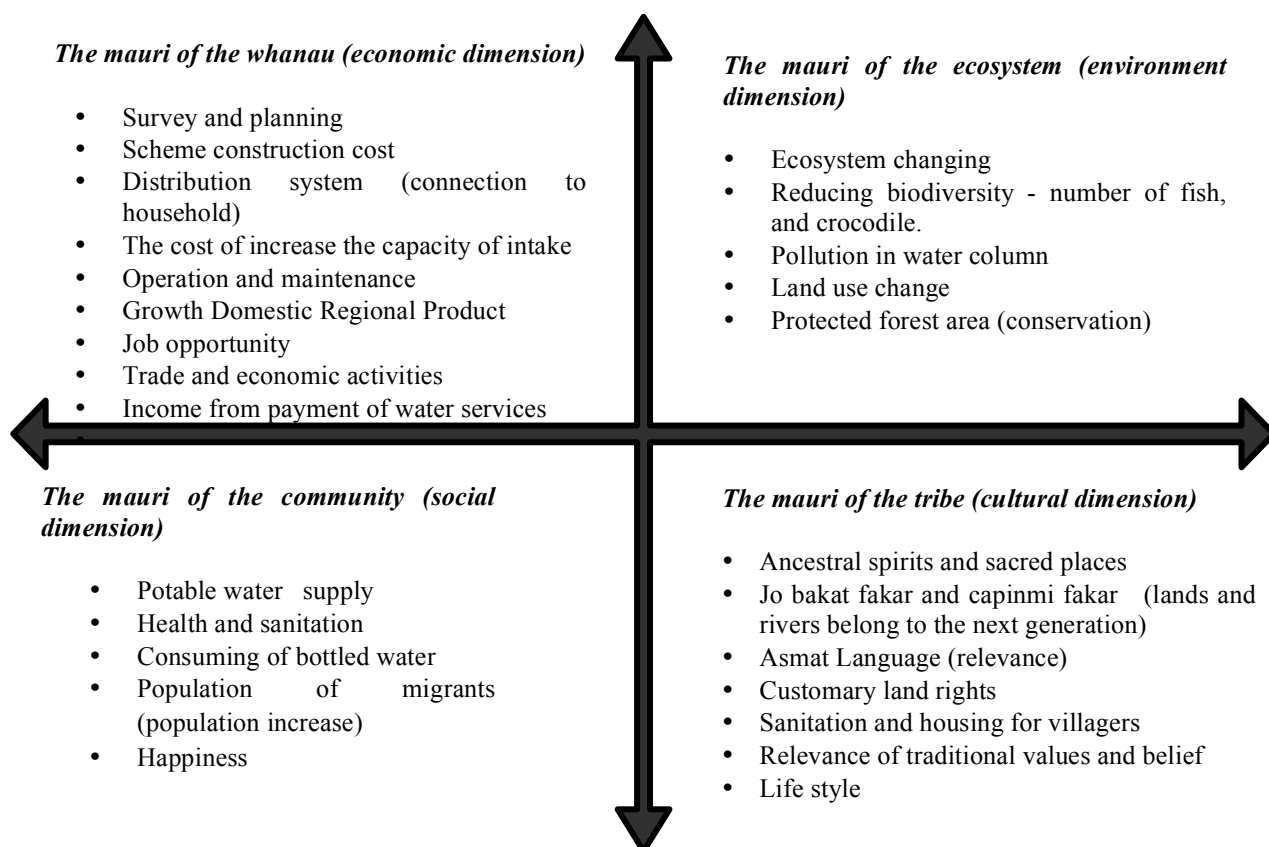


Figure 5 The indicators of mauri dimensions

Table 4 The Ranking Assessment of the Mauri Indicators

Dimensions	Indicators	2006	2011	2016	2021	2026	2031
The mauri of the whanau	Survey and Planning	-1	0	0	0	0	0
	Construction Cost of the intake and the reservoir	-2	-1	0	0	0	0
	Distribution system (connection to household)	0	-1	-1	-1	-1	-1
	The cost of increase the capacity of intake	0	0	-1	-1	-1	-1
	Operation and Maintenance	0	-1	-1	-1	-1	-1
	GDRP (Growth Domestic Regional Product)	0	0	0	0	1	1
	Job opportunity	1	1	1	1	1	1
	Trade and economic activities	0	1	1	1	1	2
	Payment for water service	0	0	0	0	0	1
<i>Average</i>		-0.22	-0.11	-0.11	-0.11	0.00	0.22
The mauri of the community	Potable water supply	-2	-1	0	0	1	1
	Personal within household	-1	-1	0	1	1	1
	Consuming of bottled water	-1	0	0	1	1	1
	Population migrants people	0	1	1	1	1	2
	Happiness (water availability for washing)	-1	-1	0	0	1	1
	<i>Average</i>		-1	-0.4	0.2	0.6	1
The mauri of the hapū	Ancestral spirits and sacred places	2	1	1	1	0	-1
	Jo bakat fakat and capinmi fakat	1	1	0	0	-1	-1
	Asmat Language practiced in Agats	1	1	0	0	0	-1
	Customary land rights	0	1	0	0	0	0
	Traditional values	1	1	0	0	-1	-1
	Sanitation and housing for villagers	0	0	1	1	1	1
	Life style	1	0	0	0	-1	-1
	<i>Average</i>		0.86	0.71	0.29	0.29	-0.29
The mauri of the ecosystem	Ecosystem integrity	1	1	1	0	0	-1
	Reducing number of fish, crocodile	1	0	0	0	-1	-1
	Pollutant in water column (increase waste water)	0	0	-1	-1	-1	-2
	Protected forest area modification for access	2	1	0	0	-1	-1
	Land use change (Urbanization expansion of Agats Township)	1	0	0	-1	-1	-1
	<i>Average</i>		1	0.4	0	-0.4	-0.8
Total	<i>Average</i>	0.159	0.151	0.094	0.094	-0.021	-0.087

### 5.1 The Economic Dimension

The economic dimension shows (see Figure 6) in the beginning of the project the area of mauri negative at 2.23 mauri years, and in 2026, it turns to be positive at 0.5505 mauri years, with the total of negative 1.6725 mauri years over the 25 years period. The trend reflects the government decision to significant investment in infrastructure construction and customary land rights and operations and maintenance cost too. This shows the commitment of the Local Government to develop the area of District of Agats. Based on the master plan (RTRW) of the Asmat (Asmat Government, 2011b, Asmat Government, 2012b), District of Agats is one of the areas which is to be developed as an economic zone. So the infrastructure, including the water supply is necessary to support the goal. The spatial planning for Papua's Infrastructure also has included the water supply project in Agats Township (Papua Government, 2013). Even though the water supply has not contributed directly to the economic sector yet, according to the GRDP of the Asmat regency, the economic growth rate of Asmat fluctuated during the period of 2007 to 2011, but is now showing signs of growth. Based on the statistical data (BPS, 2012), in 2011, only 1.27 % of GDRP came from the water supply and electricity subsector, and then only from electricity. According to historical data (Nasution, 2013) the economic growth of the Asmat regency is positive, except the sectors of the electricity, gas and water. If the water service improves the Local Government can get the customers to pay for water use because they have not decided yet when the payment will be collected. If the water supply infrastructure works well, it modifies the impact of the sector to be net positive. If the water supply can operate continuously, many water problems can be solved, and result in increased immigration to Asmat.

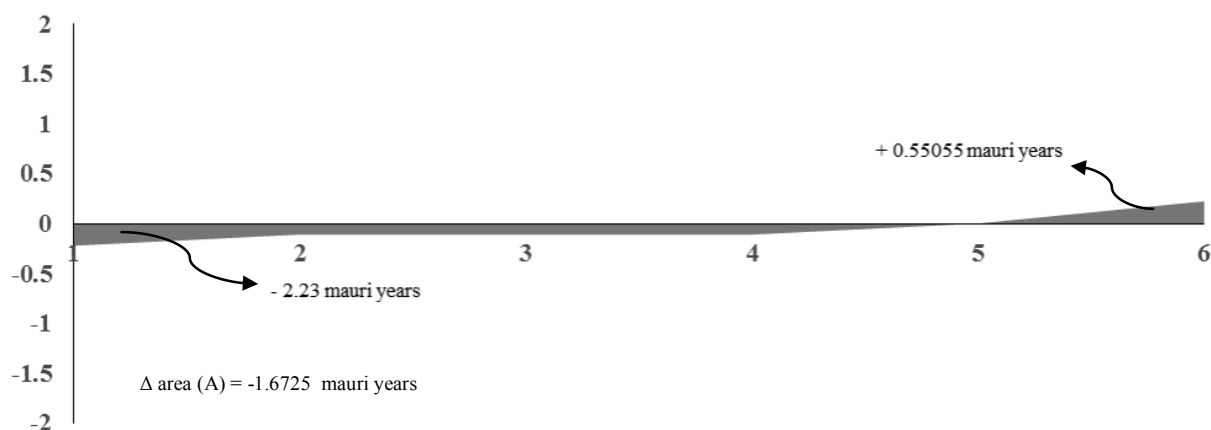


Figure 6 The mauri of the economic dimension

The infrastructure can also enhance the tourism opportunities of Asmat. Now, the economic activities are dominated by outsiders (Asdiana, 2013, Hardanto, 2012), it proves that the population increase, which means the economic activity, is improved. So even though the total area during the period of 25 is negative, but the turn positive forward and foster the achievement of Agats as an economically strategic zone of the Asmat regency.

### 5.2. The mauri of the community

The projected impact on community mauri is greater (see Figure 7). Based on the calculation, the total area of enhanced mauri for the community is +7.5 mauri years. It shows the overall impact of the mauri is positive. Although at the beginning of the project, the mauri of community was negative due to the delay for project implementation and inequities regarding access and service availability, the potable water supply should reduce the need to buy the bottled water or reduce total dependence on rainwater catchment. The project enhances the happiness of the people. The water

supply was limited; such that if there is no rain, there is no water. The government has done the best implemented the infrastructure project to provide water; however the service still has not met the needs of the entire community. The availability of the water is still a problem; and the community still depends on the rainwater (Hariyadi, 2013, Mambor, 2009, Radar-Merauke, 2008). However, once the water supply infrastructure can operate properly, the project may impact positively to the community. Several benefits are improved sanitation, reduced costs associated with bottled water, and increased the quality of life due to increased time for other activities. Based on the analysis, the social dimension turns positive after approximately in 2014, because the Local Government are planning to increase the quantity of the water supply and distribution (see Table 1). The population of Agats has increased significantly, during the period of 2005 to 2011, the population growth rate of the Asmat regency overall was 2.99 % with the highest rate in Agats at 22.04 % (BPS, 2012). It shows that Agats Town has attracted outsiders to live there. Thus, the population will increase if the water service in Agats is improved.



Figure 7 The mauri of the community

The ecosystem mauri is impacted negatively. The area impacted by the project is protected forest. The demand for water from the river causes the changing land use. To minimize the destruction of the forest, the Local Government could manage well. The mauri of ecosystem is continuing to decrease after 2016. The construction of the project diminished the forest, including vegetation. Disturbance of the natural vegetation had an influence on other species like fish and shrimps.

The increase in the number of fiber boats caused water pollution and over exploitation of the springs can foster the intrusion of salt water. To anticipate and avoid this condition, the water demand and consumption has to be calculated properly as the planned that water debit will be increased gradually. According to a previous study (Kamun, 2010); the Yomot River which 3 meter depth has a capacity of 2,302,140 m<sup>3</sup>. So the service has to consider the balance between the water demand of the Agats people and the capacity of the swamp.

### 5.3 The mauri of the environmental dimension

Changing the land use and hydrology will affect the natural habitat of the species around the fresh swampy forest. The analysis calculates -4.5 mauri-years of resilience are diminished over the project analysis timeframe. This can cause more negative impacts to the ecosystem.

These days Asmat areas have faced the impact of climate change and global warming (Bobi and Mampioer, 2010). Recently, an e-paper published an article (Suara-Pembaharuan, 2013) said that local government and WWF (World Wildlife Fund) introduced a program to do mangrove plantation in several critical areas in coastal Asmat (Mawel, 2013a). Those areas are Yepem village, Peer village and Syuru Village which part of Agats District. Informed by traditional story (Sonokos, A.T, personal interview, 11 Dec 2012) Agats once sandy land has changed to be a muddy area, and

the community (the Asmat People and outsiders) believe that this change coincided with the ‘shooting of Pastor Jan Smith’ on 28 January 1965 (Arsdale, 1975). This shows that there is a change in Agats ecosystem, which related to deforestation and opening forest for settlement. Some effort has been made by WWF to assist the recovery of the ecosystem in critical areas of Asmat including Yepem Village by planting mangroves (Suara-Pembaharuan, 2013).

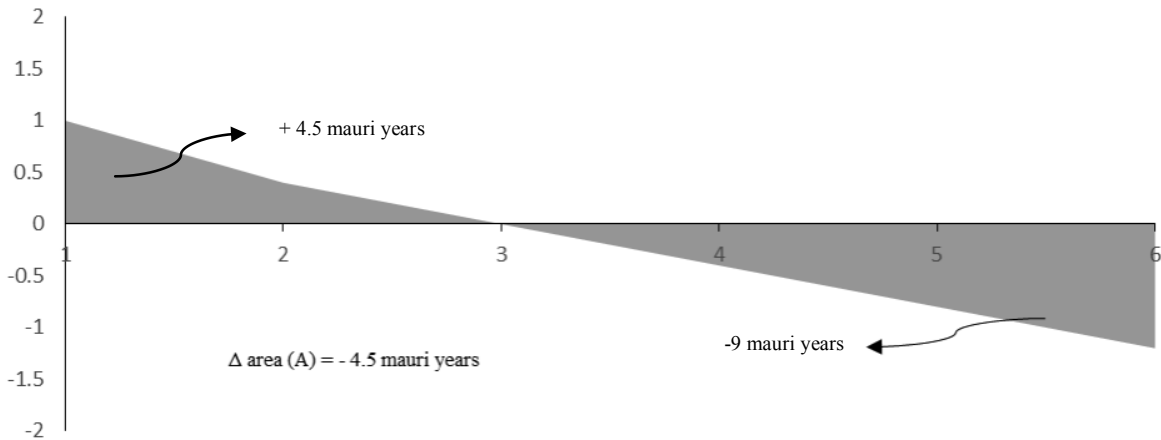


Figure 8 The mauri of the ecosystem

**5.4 The mauri of the tribal dimension**

Although the mauri of Asmat Peoples is the most positively impacted when considered in terms of total impact, the trend is negative. The net cumulative impact is determined as more than 5 mauri years; primarily because of the compensation and facilities provided by the Local Government at the beginning of the project. The actual change is a delayed one and the impact will be more enduring than that upon the ecosystem which has a greater inherent capacity to accommodate the changes that have taken place. The real change as experienced by the Asmat is significant (Arsdale, 1978, Dobratz, 2008, van der Zee, 2010) and is not recovered with time.

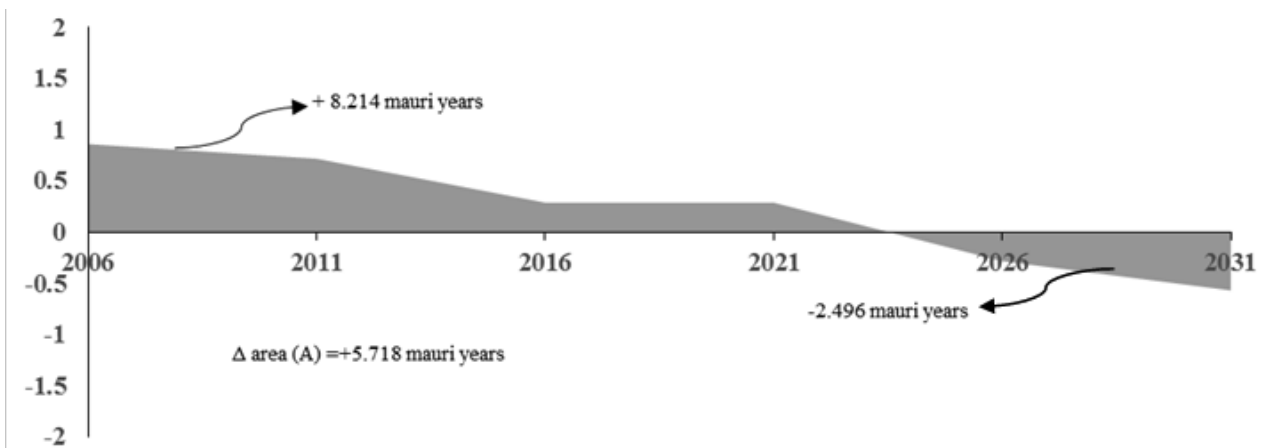


Figure 9 The mauri of the tribal dimension

At the commencement of the project the mauri dimension is positive due to the continued practices and relevance of the traditional values. Asmat people who live in the Yepem Village believe that the place of water is a sacred place called Cifa Bambu. There is a traditional story behind the Yomot River which describes a love mother to the daughter, and the river is named using the first spirit Yombotsimbit (Kaspar Manmak, 2008) . The appropriate respect of the ancestors impacts positively toward the maintenance of the cultural dimension. The position of the intake in

that sacred place is considered to negatively impact upon the value and integrity of the sacred place. The forest will be logged which also impacts on the cultural dimension. The Asmat believe water, or 'mbu' in local language, is an integral part of the culture and ecosystem. Asmat people believe the landscape and nature like rivers, trees, animals are associated with humans in an interdependent way (Jimanipits, 2012, Kaspar Manmak, 2008).

Inevitably, the consequence of the water supply infrastructure development has positive and negative impacts. One of the negative impacts is the denigration of the traditional values of the indigenous people. The intrinsic value of the place will decrease if all stakeholders do not act to maintain the intrinsic values embodied in the past management of the site. As explained, nature and Asmat people are inseparable. The people believe that they can drink directly from the river without thinking of the health aspects because they believe that their ancestors will give them immunity (Personal Communication, 2012), but the increase of population has related increased water pollution. So people have no confidence in using the water anymore. The increasing population also contributes to changing practices impacting upon the traditional Asmat values. Several activities which replace traditional values such as replacement of bamboo by plastic buckets, the use of fibreglass boat replacing traditional canoe (Hardanto, 2012), all erode the integrity and as known, that canoe has important meaning to the Asmat people (Daeli, 2012). Previously, the river sustained 142 families, who lived in Yepem village, however now they have to share with others.

**5.5. The average of the mauri dimensions**

The concept of *jo bakar fakat* and *capinmi fakat* means the land and river belong to the next generation cannot be honoured as the mauri of the ecosystem will be diminished. The analysis shows that the reduction happened after 2023. To measure the impact of the project the areas above and under calculated axis are determined. The net area is + 5.718 mauri years, and means the impact positive, however, the long-term period may bring to the reduction of the cultural values. There are a lot of potential of the culture to develop the Asmat Regency (Prasetya, 2013) including economic value of carving (Risser, 2014). Thus it is important for the Local government to maintain the culture to develop the area.

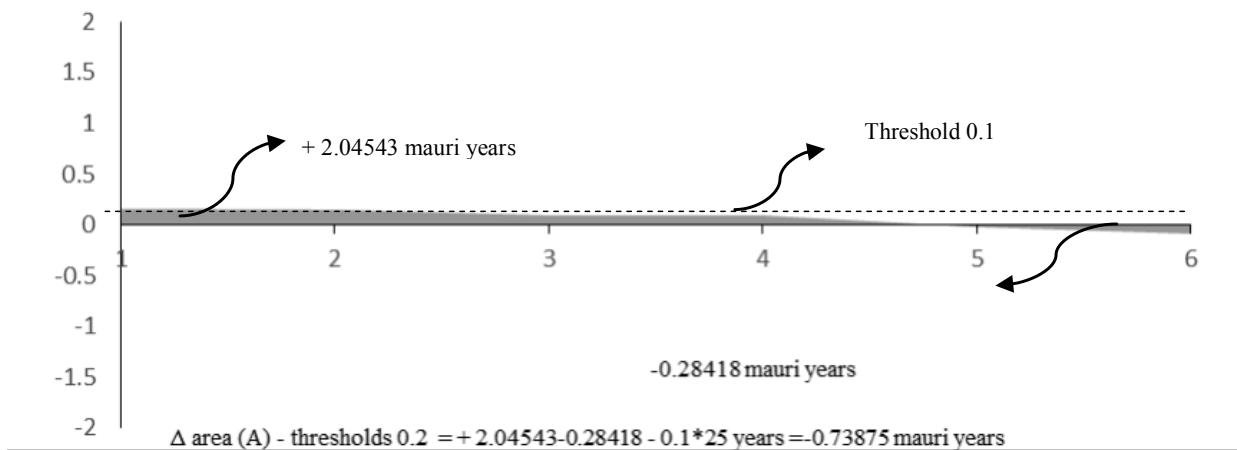


Figure 10 Average of mauri dimensions

Based on the analysis, the areas of the tribal and the community dimensions have positive impacts, while the mauri of the economic and the ecosystem dimensions are antithesis to these results. Figure 10 plots the curve for the average of the dimensions which calculates the cumulative impact upon the four dimensions. The positive impacts on the mauri of the community and the mauri of the cultural dimension show the relevance of the project to the provincial government's concept of the development of water supply infrastructure and that the water supply infrastructure should meet the basic need of the community and to foster the economic growth of the area (Papua

Government, 2013). However, the cumulative impact for all dimensions illustrates a reduction of mauri, specifically – 0.73875 mauri years. The negative impact on the averaged mauri dimensions shows the project is unsustainable over the period of 25 years with a negative trend. Even for the cultural dimension shows positive because of the effect of the customary land right. This benefits this generation, if it is evaluated longer the result will be negative, as it is shown by the negative trend from Figure 10. The result of the evaluation of the project does not achieve the goal of the Indonesian regulation of water management (UU No 7 in 2004), which states that the water management should be integrated and sustainable (Ibid 2013). The analysis should be evaluated for sensitivity to worldview bias using the quantifications of worldview determined earlier. The results of the impacts of the mauri adjusted for stakeholder perceptions are provided in Table 5 and plotted on Figure 11 and 12.

Table 5 Sensitivity Analysis

Time	2006	2011	2016	2021	2026	2031
Local Government	-0.218	-0.031	0.109	0.231	0.286	0.327
The actual mauri	0.040	0.038	0.023	0.023	-0.005	-0.087
Asmat People	0.459	0.302	0.093	0.004	-0.251	-0.408

The result shows the average combined mauri remains negative until almost the end of the analysis period of 25 years. The Local Government and the Asmat People understand this gradual negative trend differently as can be seen in the following Figure (Figures 11 and 12). Worldview quantification in Table 3 is used to modify the gradual negative trend to better represent the understanding of the different stakeholders shown in the Figure 11 and 12. The two plots in Figure 11 and 12 illustrate the validity of the decision made by the Local Government to implement the water supply infrastructure solution. The average mauri during the analysis period diminishes from 0.040 to -0.087. As explained, the trends modified for the sensitivity analysis of the two stakeholder worldviews show the opposite trends. The trend understood by the Asmat people is more pronounced in a negative direction and the trend for the Local Government is positive. For the Asmat People, there a decrease of the mauri from 0.459 to – 0.408 equal to – 0.967, while, the Local Government perceives an enhanced mauri from -0.218 to 0.327 equal to 0.545. Therefore the perceived cumulate impact of the water supply infrastructure scheme can be represented as the area (perceived) diminished or enhanced over 25 years analysis from the calculation below.

$$\begin{aligned} \text{Area of the Asmat People} = \\ (-0.967 + -0.127) \text{ mauri} * 25 \text{ years} = -24.8324515 \text{ mauri years} \approx -25 \text{ mauri years} \end{aligned} \quad (3)$$

$$\begin{aligned} \text{Area of the Local Government} = \\ (0.545 + -0.127) \text{ mauri} * 25 \text{ years} = 10.45634921 \text{ mauri years} \approx 10.5 \text{ mauri years} \end{aligned} \quad (4)$$

The mauri of tribal dimension and the mauri of community dimension are enhanced during this time frame. However, based on the sensitivity analysis results, it is evident that the infrastructure project will diminish the mauri of the Asmat People, while it enhances the mauri of the dimensions most important to Local Government. This represents a transfer of “well-being” or mauri over the 25 year timeframe. The calculation shows that for almost 50 % of the 25 year time period, the Asmat people experience a diminishing mauri and the results are aggravated the longer the timeframe. It is not only the cultural dimension that is negatively impacted, but the ecosystem dimension also, as previously the Agats Township was sandy but now due to sedimentation, it is a muddy town.

The Asmat People has been experienced a fast change since contacted with outsiders during the period of the Dutch Colonial, and continued to Indonesian Government (Arsdale, 1978, Asdiana, 2013, Dobratz, 2008, Hardanto, 2012, Konrad et al., 2002, Risser, 2014, UNDP\_Almamater, 2005, Stanley, 2007) either positive or negative changes. The changes include the cultural values and the

ecosystem. They change how their dress (van der Zee, 2010), the carving as economic purpose and the way of their life. They prefer using fibre boats than canoe (Hardanto, 2012). The Agats Township have changed dramatically since Asmat became a new regency (I.L., 2002), such a study states (de Hontheim, 2010) in 2001 , the area still a remote village, but 2004 a lot change landscape, especially new settlement of the government officers, in the same year, approximately 23 Ha of customary land area had been released to the Local Government (Ibid 2010). They also cannot compete with outsider in economic activities and working as government officers, there is a controversial life between them with the migrants (Asdiana, 2013, UNDP Almamater, 2005).

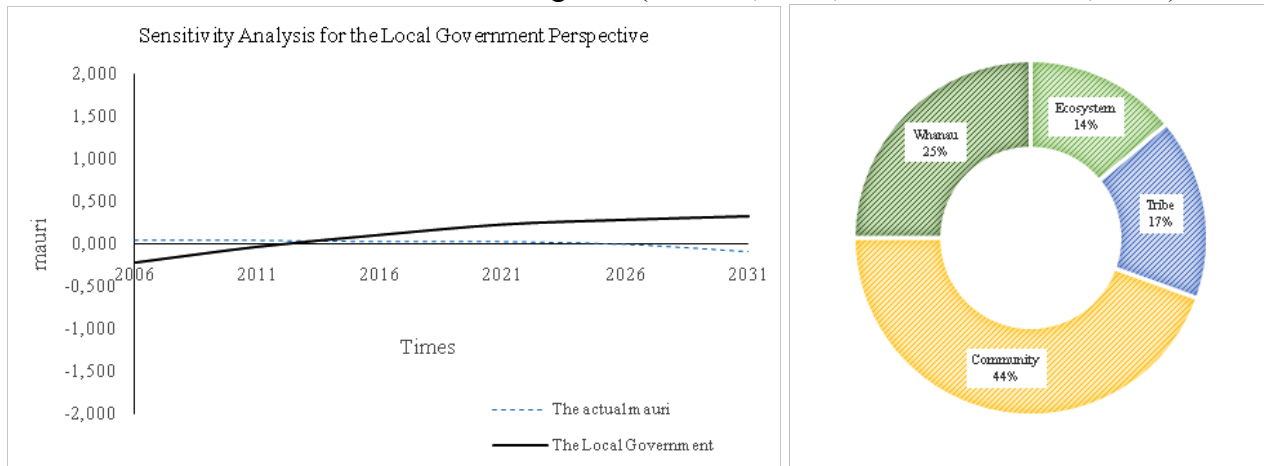


Figure 11 The Local Government's Perspective

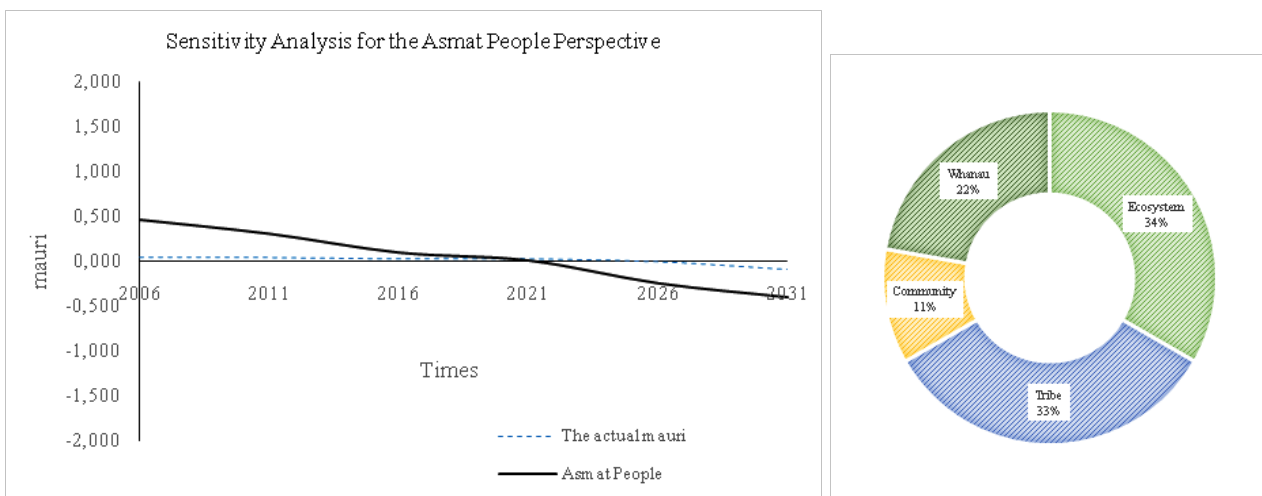


Figure 12 The Asmat People's Perspective

Inevitably, development of the Asmat Regency should be done, the change cannot be avoided. The main purpose of the water supply project to provide the social welfare for the whole community, however, it still has been achieved the equitable distribution for all people. As explained before, the zones are divided to 3 parts in the urban centre of Agats, which most population are migrants and the government officer's houses, while most the Asmat People live in suburb in Syuru Village (see Figure 4) which 10 to 15 minutes walking from the centre town.

Even though, there is a positive impact upon mauri according to Local Government perspective, the actual outcome is not, because water still cannot be available all of the time for all of the community (Hariyadi, 2013). Thus, the Local Government has to complement the infrastructure with other solutions. For example, the Asmat area has huge potential for rainfall harvesting, so an opportunity exists for the government to develop methods to maximise the collection of rainwater as practiced in other locales (Jha et al., 2014, Mbilinyi et al., 2005, Wilbers et al., 2013). To



increase the mauri Local Government can take contribution from the community which influences the GRDP. To offset the lost mauri-years of impact upon the Asmat People, the Local Government should consider the Indigenous people who live around the Syuru Village, the village between Yomot River and Agats Town because the main distribution pipe passes by this village but still has not installed the pipes for distribution in Syuru Village when the observation of this research conducted in 2012. The observation also showed that there is no adequate sewerage system, which the water straight discharge to ground which pollute the water surface. Thus the Local Government should improve the sewerage system too in order to enhance the mauri of the ecosystem. The final analysis of the Mauri Model Decision Making Framework is to display the results on the mauriOmeter (Figure 13).

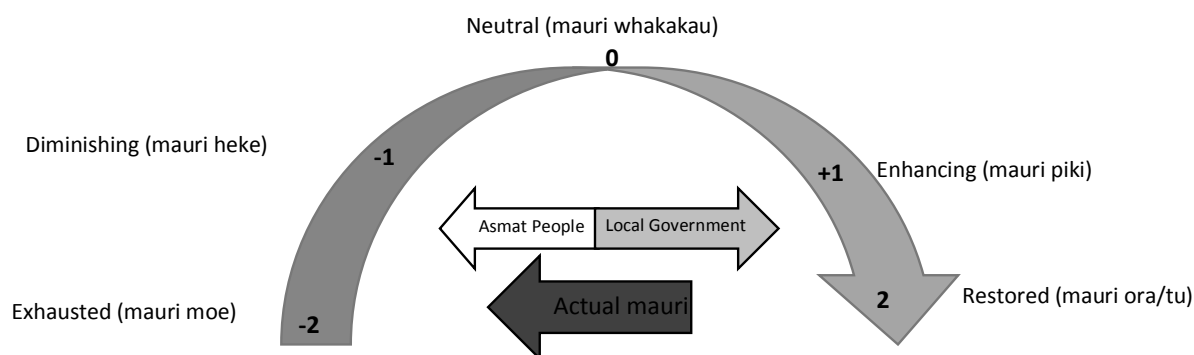


Figure 13 The mauriOmeter result

The mauriOmeter analysis of the Asmat people's perspective is consistent with the equally weighted analysis and shows a negative trend, which means that the infrastructure project is unsustainable. The Mauri Model Decision Making Framework based assessment shows that the project is not sustainable from the Asmat People's perspective, but it is considered sustainable by the Local Government.

## 6. CONCLUSION

The result of the Mauri Model Decision Making Framework shows that taking water from the Yomot River for water supply in Asmat is not sustainable. The situation is more emphatically understood from the Asmat People's perspective, but conversely the project is considered sustainable by the Local Government. The project benefits the social and economic dimensions, while the environmental and cultural dimensions are diminished. For a better solution, it is important to involve the indigenous people in any decision making which impacts on their land in the future. Further negotiations between the Asmat People and the Local Government are required to ensure the sustainability of the culture and ecosystems of Asmat.

To uphold the principle of the natural justice and duty, it is necessary to recognise the legal obligations placed upon the Local Government and future effort is necessary to ensure the benefits are equitably distributed, as an example providing public hydrants. Finally a monitoring process should be established that evaluates the impacts of the water supply infrastructure project in 2014 and 2016 when decisions to increase the water take are to be confirmed. This evaluation could be undertaken using the Mauri Model and the indicator set created for this analysis.

## REFERENCES

Agatsbishop 2014. Geografis and Demografis [Online]. Agats,Asmat. Available: <http://keuskupanagats.org/profil/geografis-dan-demografis> [Accessed 1 Jan 2015 2015].

- Arsdale, P.W.V. 1975. Perspective on Development in Asmat In: TRENKENSCHUH, F. A. (ed.) An Asmat Sketch Book 5. The Asmat Museum Of culture and Progress.
- Arsdale, P.W.V. 1978. Population Dynamics among Asmat Hunter-Gatherers of New Guinea: Data, Methods, Comparisons. *Human Ecology*, 6, 435-467.
- Asdiana, I.M. 2013. Wajah Asmat di Agats. Kompas (online). Available: <http://travel.kompas.com/read/2013/10/21/1315320/Wajah.Asmat.di.Agats>.
- Asmat Government 2011a. Laporan Akhir Peninjauan Kualitas Air Sungai Kabupaten Asmat 2011. Agats.
- Asmat Government 2011b. Rancangan Peraturan Daerah No ....Tahun 2011 tentang Rencana Tata Ruang Wilayah Kabupaten Asmat 2011-2031. Agats.
- Asmat Government 2011c. Status Lingkungan Hidup Daerah Kabupaten Asmat (The Environmental status of the Asmat Regency). In: Bappeda (ed.). Agats.
- Asmat Government 2012a. RPJMD (Rencana Pembangunan Jangka Menengah Daerah) Kabupaten Asmat Tahun 2011-2015 or The Mid term of The Saptial Planning of The Asmat Regency 2011-2015. In: BAPPEDA (ed.) Peraturan Daerah (Perda) No 9. Agats.: Bappeda.
- Asmat Government 2012b. RTRW (Rencana Tata Ruang dan Wilayah ) Kabupaten Asmat 2012-2032. In: Bappeda (ed.) Peraturan Daerah (Perda) No 6. Agats.: BAPPEDA.
- Asmat Government 2012c. Study Pemanfaatan Air sungai Asuwesty Menjadi Sumber Air Bersih Kota Agats Kabupaten Asmat. In: Department, P. W. (ed.). Agats: CV Anuta Pura ( Konsultasi Teknik,Lingkungan dan Managemen).
- Bell, D. & ROWE, F. 2012. Are climate policies fairly made, York: Joseph Rowntree Foundation.
- Bigourdan, N. 2006. Physical and spiritual voyages: An ethno-archaeological approach to the study of Asmat canoes (Irian Jaya, Indonesia). *AIMA Bulletin*, 30, 15.
- Bobi, W. & Mampioer, D. 2010. Abrasi Ancam Pantai dan Pemukiman Warga. *TabloidJubi*, 22 May 2014.
- BPS Asmat 2012. Asmat Regency in Figures, Agats,Asmat, BPS (Statistics of Asmat Regency).
- BPS Asmat 2013. Asmat Dalam Angka (Asmat in Figure ). Agats: BPS (Badan Pusat Statistics) or Statistical Beauraeu
- Cardoso, R. & Breda-Vázquez, I. 2009. The institutionalization of just decision making: analyzing planning practice in Portugal. *Environment and planning, C, Government & policy*, 27, 413.
- Challenger, I. 2013. A Process for Developing Sustainability Indicator Sets.Prepared for Ministry of Business, Innovation and Employment. Cawthron Report No.2224.44 p. .
- Daeli, O. 2012. Ci Opak, Jis Opak (No Canoe, No Firewood) an economic dimension of the Asmat Canoe. *Melintas*, 28, 20.
- Daeng, M.F. 2012. Agats Menjaga Alam, Panen Air. *Kompas*, 30 November 2012.
- Davidson, J. 1990. General Characteristics of Irian Jaya and Its Prospects for development. *Irian*, 18, 17.
- De Hontheim, A. 2010. Should Time End and Begin? Asmat Temporality in a Changing World.
- Dobratz, L. 2008. The changing Asmat world: a survey of cultural and artistic change from 1950-2001. Master, Wichita State University
- Fa'au, T.N. & Morgan, T.K.K.B. 2014. Restoring the Mauri to the Pre - MV Rena State. *MAI*, 3, 15.
- Giesen, W. & Houterman, J. 2009. Sustainable Management of wetlands in Papua. 1St International biodiversity Conference on sustainable development in the land of Papua. Jayapura ,papua: draft.
- Goldbarth, A. 2006. Wuramon. *The Iowa Review*, 36, 62-77.
- Hardanto, D.J.S. 2012. Asmat dan Perubahan Kompas.com (Online), 23 October 2012.
- Hariyadi, M. 2013. Kisah Agats Asmat: Hujan Jadi Nafas dan Sumber Kehidupan (6). *Sesawi Net* [Online]. Available from: <http://www.sesawi.net/2013/07/12/kisah-agats-asmatahujan-jadi-nafas-dan-sumber-kehidupan-6/> 2014].
- Hawkins, D.E. 2004. Sustainable tourism competitiveness clusters: application to World Heritage sites network development in Indonesia. *Asia Pacific Journal of Tourism Research*, 9, 293-307.
- Indonesian Government, Hidro-Oceanografi, D., Dinas, H. & Jawatan, H.-O. 2011. Daftar pasang surut Kepulauan Indonesia Tide tables, Indonesian Archipelago. In: Hidro-Oceanografi, D. (ed.) Daftar pasang surut Kepulauan Indonesia Tide tables, Indonesian Archipelago. Jakarta: Department Hidrografi TNI Angkatan Laut (Indonesian Navy).
- Jha, M.K., Chowdary, V.M., Kulkarni, Y. & Mal, B.C. 2014. Rainwater harvesting planning using geospatial techniques and multicriteria decision analysis. *Resources, Conservation and Recycling*, 83, 96-111.
- Jimanipts, D. 2012. Kumpulan Cerita Rakyat Asmat, Agats (Asmat), Cultural and Tourism Department of Asmat Regency.
- Kar, D. 2013. Wetlands of Other Regions in Asia. *Wetlands and Lakes of the World*. Springer.
- Kaspar Manmak (ed.) 2008. Folklore (Pada Komunitas Rumpun Bismam Asmat), Yogyakarta: Biagraf.
- Koentjaraningrat 1989. *The Asmat of South Irian Jaya*. Indonesia Circle, 50, 16.
- Konrad, G. 1981. Asmat: life with the ancestors: stone age woodcarvers in our time / von Gunter Konrad, Ursula Konrad, Tobias Schneebaumhrsg. von Friedhelm Brückner, Glashütten/Ts. Druck
- Konrad, U., Sowada, A. & Konrad, G. (eds.) 2002. *Asmat : Mencekap Kehidupan Dalam Seni*, Greven, German: Druckhaus Cramer., Latief, A.A.M. 2005. Keunikan Agats Sebagai "Kota Panggung". *RONA Jurnal Arsitektur*, 2, 12.
- Lubis, B.U. 2012. Agats: The Waterfront City of the Asmat. *Nakhara: Journal of Environmental Design and Planning*, 6.
- Mambor, V. 2009. Sorotan DPRD Asmat: Pelayanan Pembangunan Masih Minim. *TabloidJubi* (online), 10 October 2009.
- Mansoben, A.J. 2006. The The socio-cultural Plurality of Papuan society. In: MARSHALL, A. J. & BEEHLER, B. M. (eds.) *The ecology of Papua*. Singapore: Periplus.
- Mansoben, J.R. 1995. Sistem politik tradisional di Irian Jaya, LIPI\_RUL.
- Mawdsley, N. & Houterman, J. 2010. RE: Spatial Planning and Southern Lowlands of Papua.
- Mawel, B. 2013a. WWF Asmat Terus Memperluas Restorasi dan Pemetaan. *Tabloidjubi.com* [Online]. [Accessed 19 Dec 2013].
- Mawel, B. 2013b. WWF Berhasil Melakukan Pemetaan Hutan Asmat. *TabloidJubi* (online), 2 July 2013.
- Mbilinyi, B.P., Tumbo, S.D., Mahoo, H.F., Senkondo, E.M. & Hatibu, N. 2005. Indigenous knowledge as decision support tool in rainwater harvesting. *Physics and Chemistry of the Earth, Parts A/B/C*, 30, 792-798.

- Molle, F. 2009. River-basin planning and management: The social life of a concept. *Geoforum*, 40, 484-494.
- Morgan, T. 2006a. Decision-support tools and the indigenous paradigm. *Proceedings of the ICE-Engineering Sustainability*, 159, 169-177.
- Morgan, T.K.K.B. 2004. A Tangata Whenua Perspective on Sustainability using the Mauri Model: Towards decision making balance with regard to our social, economic, environmental and cultural well-being. In: Unpublished document. Presented at the International Conference on Sustainability Engineering and Science: Auckland, New Zealand.
- Morgan, T.K.K.B. 2006b. An indigenous perspective on water recycling. *Desalination*, 187, 127-136.
- Morgan, T.K.K.B. 2008. The Value of a Hapū Perspective to Municipal Water Management Practice: Mauri and potential contribution to Sustainability Decision Making in Aotearoa New Zealand. *ResearchSpace@ Auckland*.
- Morgan, T.K.K.B., Sardelic, D. N. & Waretini, A. F. 2012. The Three Gorges Project: How sustainable? *Journal of Hydrology*, 460, 1-12.
- I.L. (Indonesian Law) No 26, 2002 (UU No 26 Tahun 2002).
- Nasution, N. 2013. Analisis Perubahan Struktur Ekonomi Di Kabupaten Asmat Provinsi Papua (Economic structure analysis of Changes in District Asmat, Papua, Province. *Sosio-Agri Papua Publikasi Ilmu-ilmu Social Ekonomi Pertanian*, 2, 9.
- Paoletti, M. G. 1995. Biodiversity, traditional landscapes and agroecosystem management. *Landscape and Urban Planning*, 31, 117-128.
- Papua-Government 2013. *Profil Papua*. Jayapura.: Bappeda- Papua.
- Papua Government 2013. RIPI (Penyusunan Detail Rencana Induk Pembangunan Infrastruktur Provinsi Papua 2011-2013). In: Bappeda-Papua (ed.). Jayapura: Bappeda Papua,.
- Pintér, L., Hardi, P., Martinuzzi, A. & Hall, J. 2012. Bellagio STAMP: Principles for sustainability assessment and measurement. *Ecological Indicators*, 17, 20-28.
- Ponzetta, M. T. & Paoletti, M. G. 1997. Insects as food of the Irian Jaya populations. *Ecology of food and nutrition*, 36, 321-346.
- Prasetya, L. E. 2013. Budaya Lokal Sebagai Potensi Dalam Pengembangan Kawasan Ekonomi Khusus (KEK) Kabupaten Asmat. *Radar-Merauke*. 2008. Menelusuri Kota Agats Kabupaten Asmat. *Radar Merauke* (online), 6 Dec 2008.
- Risser, J. 2014. The making of Asmat art: Indigenous art in a world perspective, by Nick Stanley. In: *Anthropological Forum*. Taylor & Francis.
- Robert, M., Norman, W., Minhinnick, N., Wihongi, D. & Kirkwood, C. 1995. *Kaitiakitanga: Maori Perspectives on Conservation*. *Pacific Conservation Biology*: , 2, 14.
- Saaty, T. L. 1980. *The Analytic Hierarchy Process*, New York, McGraw-Hill International Book Co.
- Schneebaum, T. 1988. *Where the spirits dwell : an odyssey in the New Guinea jungle* / Tobias Schneebaum, New York : Grove Press, 1988.
- Schneebaum, T. 1990. *Embodied spirits : ritual carvings of the Asmat* / Tobias Schneebaum, Salem, Mass.: Peabody Museum of Salem.
- Schneebaum, T. 2000. *Secret places : my life in New York and New Guinea* / Tobias Schneebaum, Madison : University of Wisconsin Press, c2000.
- Shmueli, D. F. 1999. Water quality in international river basins. *Political Geography*, 18, 437-476.
- Simon, K. 1977. Asmat Art: Seventy years of Asmat woodcarving. *Pacific Arts Newsletter*, 9-11.
- Smidt, D. 2013. *Asmat Art: Woodcarvings of Southwest New Guinea*, Tuttle Publishing.
- Stanley, N. 2007. Can Museums become Indigenous? *The Asmat Museum of Culture and Progress and Contemporary Papua*. *The Future of Indigenous Museums: Perspectives from the Southwest Pacific*, 1, 190.
- Suara-Pembaharuan. 2013. Menyelamatkan Hutan Asmat dengan Restorasi Ekosistem [Online]. Available: <http://sp.beritasatu.com/home/menyelamatkan-hutan-asmata-dengan-restorasi-ekosistem/37907> [Accessed].
- Tanguay, J. 2012. *Alternative Indicators of Well-being for Melanesia*. Port Vila, Vanuatu: Malvatumauri National Council of Chief.
- Tommaseo, M. & Lucchetti, E. 1992. Anthropometrical study of the Asmat (Irian Jaya). *Anthropologischer Anzeiger*, 50, 217-234.
- UNDP Almamater 2005. *Kajian Keberadaan dan Kapasitas CSO/CBO serta Perikehidupan Berkelanjutan Pada 4 Kabupaten di Wilayah Papua Selatan*. Merauke: Yayasan Almamater Merauke & UNDP (United Nation Development Programme).
- Van Der Zee, P. 2010. Asmat dress. *Australia, New Zealand, and the Pacific Islands*, 7, 471-478.
- Wambrauw, E.V. & Morgan, T.K.K.B. 2014. Concept alignment for sustainability: Relevance of the Mauri Model in Asmat, Southern Papua.
- Wambrauw, L.T. 2013. *Indigenous Entrepreneurship by Papuan Women in the Informal Agricultural Sector in Manokwari - West Papua Province in Indonesia*. Doctor of Philosophy Lincoln University.
- Wilbers, G.-J., Sebesvari, Z., Rechenburg, A. & Renaud, F. G. 2013. Effects of local and spatial conditions on the quality of harvested rainwater in the Mekong Delta, Vietnam. *Environmental Pollution*, 182, 225-232.