

An architectural rendering of a park named 'Resilient Bento Rodrigues'. The scene features a prominent wooden boardwalk with railings that winds through a lush, green landscape. In the foreground, a man in a white shirt and a hat stands on the boardwalk. Further back, a group of people, including a woman in a white dress, a child, and a man, are walking. The background shows a large, grassy hill with scattered trees under a blue sky with white clouds. The overall atmosphere is bright and sunny.

RESILIENT BENTO RODRIGUES

Sustainable Urban Design

Master Programme

Spring 2018

Thesis Project by Priscila Portugal Jorge

Supervisor: Andreas Olsson and Rogerio Palhares



LUND
UNIVERSITY

Master Degree in Sustainable Urban Design

School of Architecture, Lund University

Resilient Bento Rodrigues

Bento Rodrigues, Brazil

Student: Priscila Portugal Jorge

Supervisor: Andreas Olsson and Rogerio Palhares

Tabel of contents

1. SUMMARY.....	4	8.10. Detail Plan.....	65
2. RESEARCH FRAMEWORK.....	5	8.11. Images of the park.....	64
2.1. Research Problem.....	5	8.12. Identity in the typologies.....	66
2.2. Research Questions.....	6	9. Options for flexibility.....	67
3. CONTEXT.....	6	10. Conclusion.....	68
3.1. Brazil.....	6	11. Annex	69
3.2. Minas Gerais.....	11		
3.2 History of Mining in Minas Gerais.....	15		
4. Mariana.....	17		
5. SAMARCO.....	19		
6. Bento Rodrigues.....	20		
6.1. Disaster.....	20		
6.2. The damages:.....	28		
7. The profile of population.....	29		
7.1. Style of living.....	30		
7.2 New location for Bento Rodrigues.....	33		
7.3. The reasons why Lavoura site was chosen.....	35		
7.4. SWOT.....	39		
8. THE PROPOSAL.....	40		
8.1. The nature concept:.....	41		
8.2. Sustainability.....	43		
8.3. Identity:.....	44		
8.4. Analysis of the site:.....	45		
8.5. Biome.....	46		
8.6. Physical Analysis.....	47		
8.7. Regulations.....	50		
8.8. The process for the proposal.....	51		
8.9. Masterplan.....	62		

1. SUMMARY

The aim of the project is the reconstruction of the district Bento Rodrigues located in the state of Minas Gerais; Brazil destroyed by the collapse of a mining dam Fundão in November 2015. This disaster was one of the biggest tragedy in the country. Mud covered the village, a river flooded and all the waste arrived until the Atlantic Ocean, including one of the most important rivers, the Rio Doce. This disaster killed around 20 people. It damaged fauna and flora besides it made the water undrinkable for the area and for all the cities the river passes close. The new site of the reconstruction is 8 km far away from the urban center, Mariana. This site was chosen by the locals together with the company responsible for the disaster. It is not possible to rebuild the village in the old place because it is dangerous, another dam in the area can collapse.

The proposal seeks to rebuild the village based on three points: nature, sustainability, identity. The reconstruction will be having a balance with nature and the new town, that provides a low density and more integration with the landscape. Another aspect of the economy should create a small brick industry using the mud of the disaster to rebuild the city, with a partnership of the Federal University of Minas Gerais. The sustainability is to reuse the rainwater for agriculture to improve the local economy and provide more jobs for the locals. The concept of identity will be found in the typologies of housing, where people can build a part of their houses and have more connection to the place.

2. Research Framework

2.1. Research Problem

Bento Rodrigues was founded in the 17th. Century for gold mining purposes in the region and has grown to a population considerably until the gold crisis at the end of the 18th. Century. From then on, the village has always had a slow development and has kept its traditional culture and way of life.

During the extraction of the gold, mine ore has found and many transformation industries set up in the region in 1814. Since that time, the area has also been developed with the exploration of other minerals and new companies established in the local. In 1920, the president of Brazil, Artur Bernardes promoted the national metallurgy. In 1940, the rights of the mines in Itabira were given to Brazilian Government, then two years after, the Company Vale do Rio Doce was created. Decade 60, the Brazilian mineral sector was opened for foreigner capital. In that context, many companies came out such as MBR, Samitri, Alcoa, Usiminas, etc.

In November 2015, the mining dam Fundão collapsed and destroyed the village. Around 20 people died, and another 400 lost their

houses. The company responsible for the dam, Samarco was sewed, punished and forced to rebuild the city as a way to compensate the damage to the residents and their assets. There are some historical and heritage landmark fragments left in the townsite such as 2 ruined colonial churches from which researchers are trying to rescue religious sculptures, images and other objects to be restored. The village is also famous for tourism in the region and the country because it is part of the Royal Route, a path that Portuguese used to transport gold from Minas Gerais to Rio de Janeiro, and then to be shipped to Portugal.

The thesis seeks to do an urban design for the village Bento Rodrigues in social and architectural sustainable way.

2.2. Research Questions

This research aims to understand Bento Rodrigues's residents' needs and aspirations towards the new town and how could be a master plan which it can translate in lines these concepts in social and in architectural sustainability. Another aspect to be considered is to rebuild the ancient churches in the same way to keep the identity. The current research and the design proposal that follows it seeks to create a new Bento Rodrigues in a different site but in compliance to the residents' desires and according to the local topography. Especially, because the region's relief has high declivity and the proposed subdivision plan has to comply with Federal Law 6766, that is not allowed to build in steep slopes, flood hazard areas, conservation units and other environmental constraints. This master plan has some urgency since all residents are living in temporary dwellers and hotels in Mariana.

3. Context

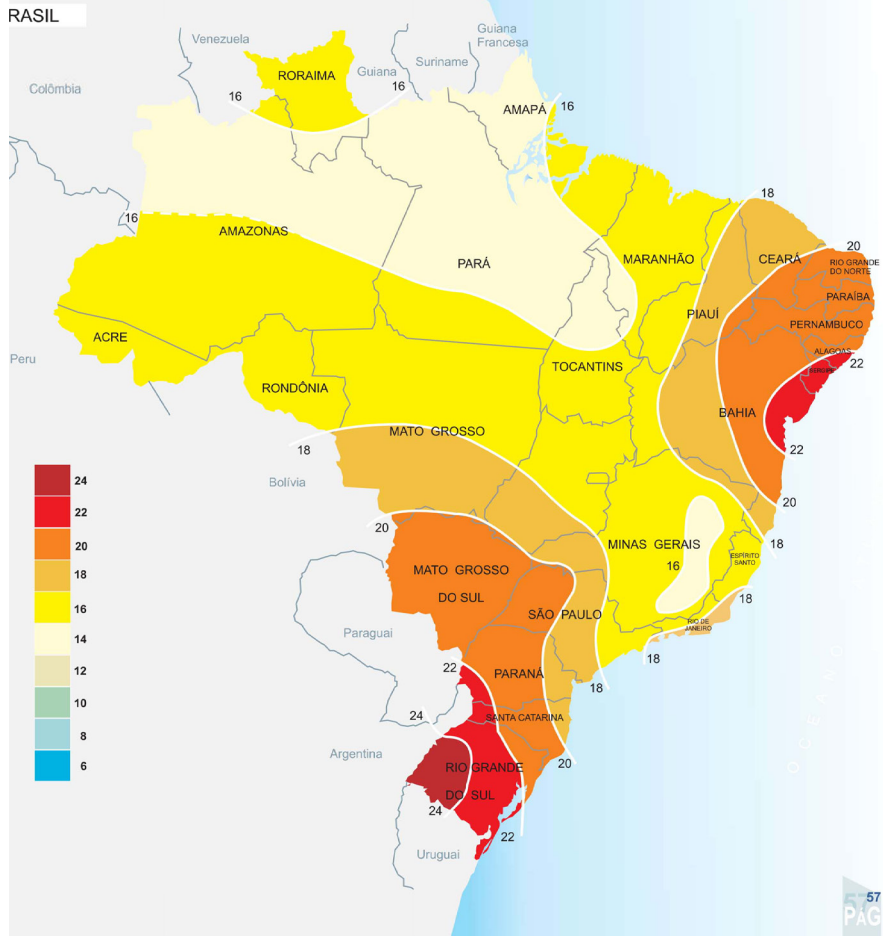
3.1. Brazil

Brazil is located in South America. It was colonized in 1500 by Portuguese, Alvares Cabral. The climate is almost tropical for the whole country since it has by two seasons: the rainy one and the dry one. Brazil has a population of 200 million people and a territorial surface of 9.000.000 km². The majority of its population is concentrated in the southeast region, which includes Minas Gerais, São Paulo, Rio de Janeiro and the Espírito Santo States. The HDI is very low when compared with the developed countries; Brazil is 79^o position in the world ranking. The sustainability is weak because of few public investments. Otherwise, the country has a lot of potentials to use solar energy because it has an average of 200 days of sun in the year.

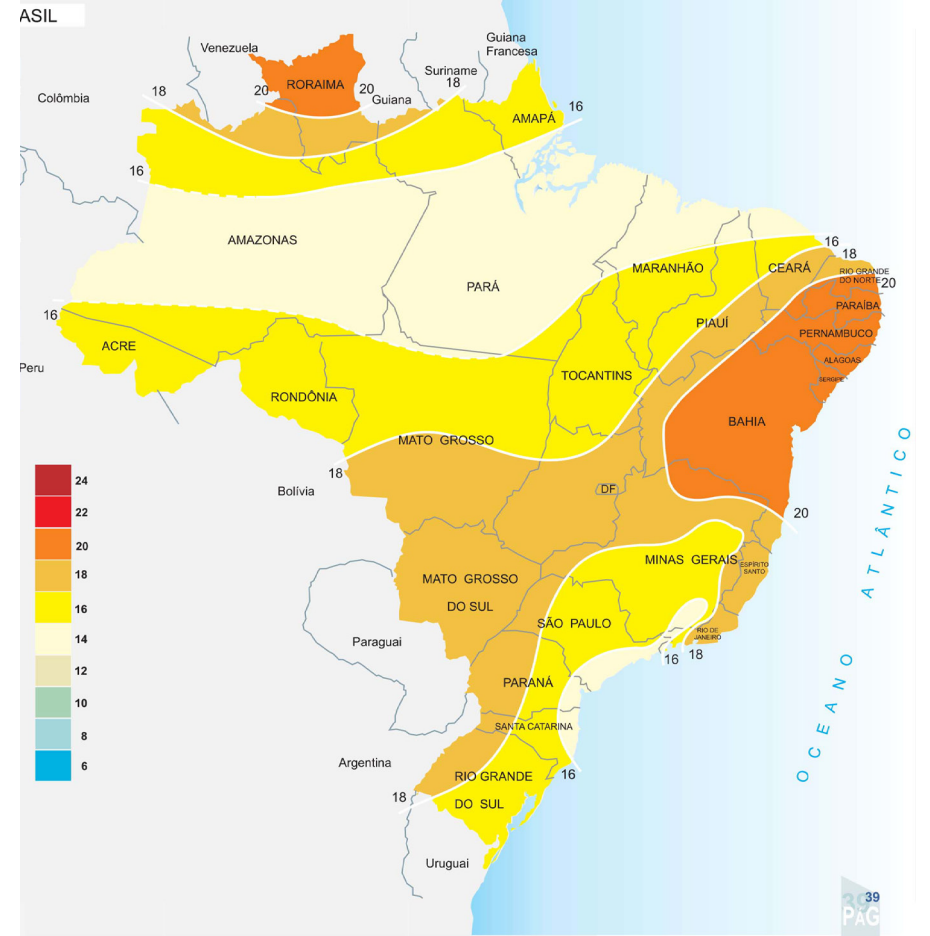
- Federative Republic
- Divided in 26 states and
1 federal district
- Language: Portuguese
- Capital: Brasília



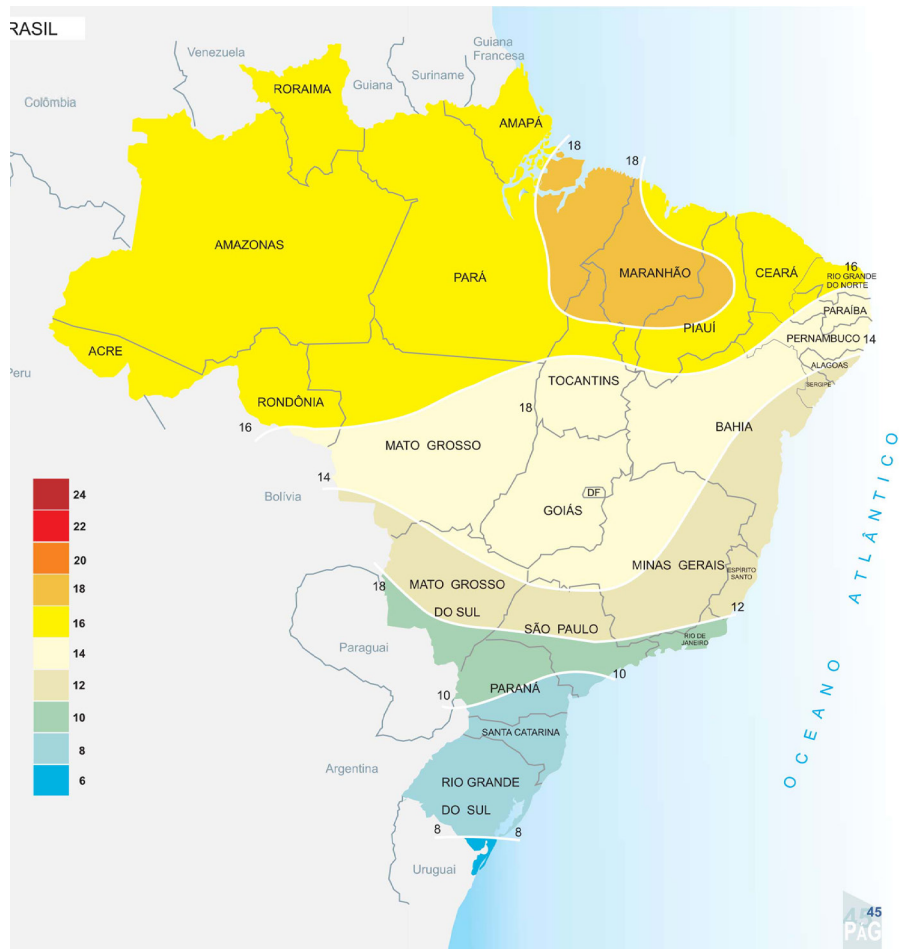
Img. 1 Location of Brazil
Available at: <https://pt.wikipedia.org/wiki/Brazil>
Accessed: 10 January 2018



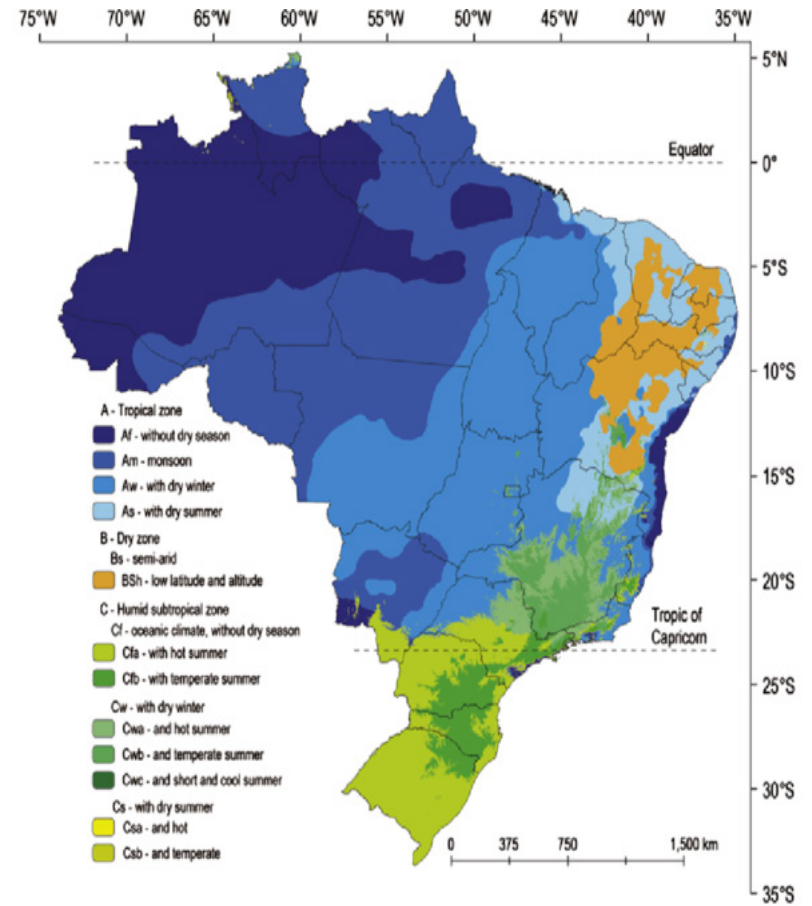
Img. 2 Solar analysis in December
 Available at: http://www.cresesb.cepel.br/publicacoes/download/Atlas_Solarimetrico_do_Brasil_2000.pdf Accessed 10 Jan 2018



Img. 3 Solar analysis in March
 Available at: http://www.cresesb.cepel.br/publicacoes/download/Atlas_Solarimetrico_do_Brasil_2000.pdf Accessed 10 Jan 2018

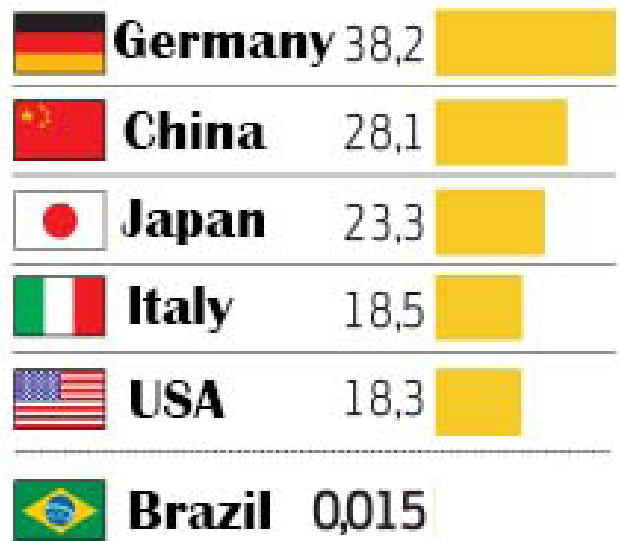


Img. 4 Solar analysis in June
 Available at http://www.cresesb.cepel.br/publicacoes/download/Atlas_Solarimetrico_do_Brasil_2000.pdf Accessed 10 Jan 2018



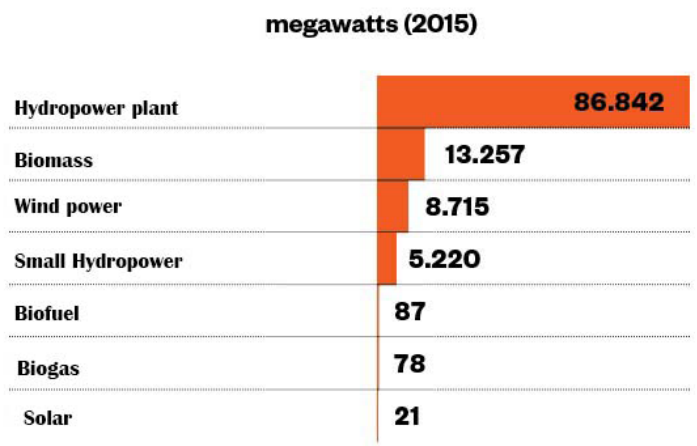
Img. 5 Temperature in Brazil
 Available at https://www.researchgate.net/figure/Climate-classification-for-Brazil-according-to-the-KOPPENKOKOPPEN-1936-criteria_fig4_263088914 Accessed 10 Jan 2018

Solar Energy in Gw (2014)



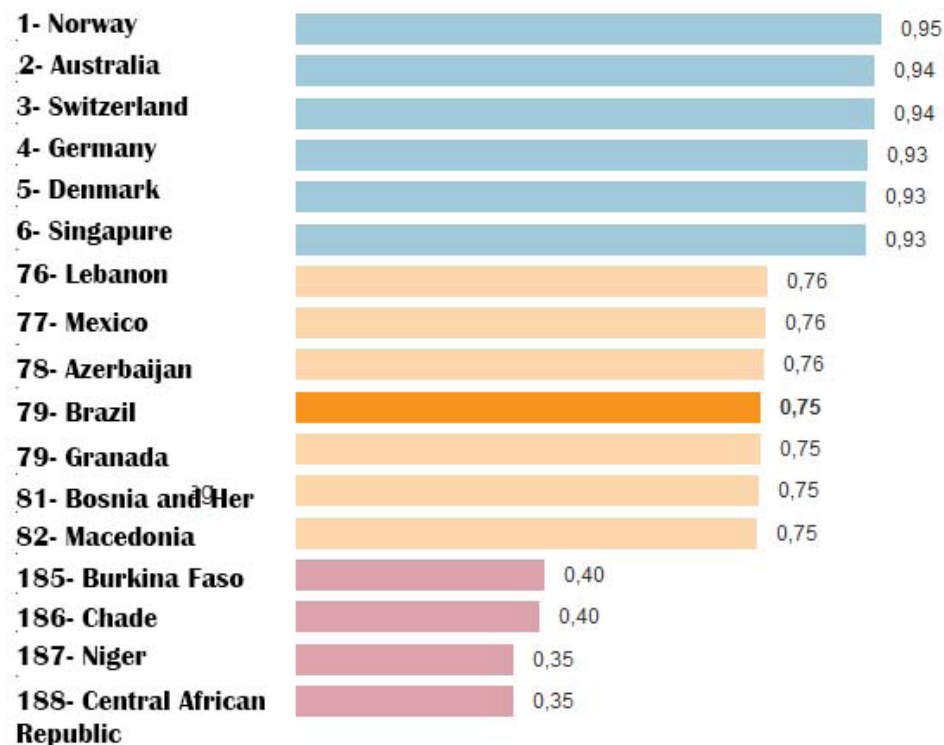
Imag 6-Solar Energy in GW
 Available at: <http://www.sunvoltenergiasolar.com.br/por-que-a-energia-solar-deve-decolar-em-2016-no-brasil/dados-geracao-solar/> Accessed 10 Jan 2018

Types of renewable Energy

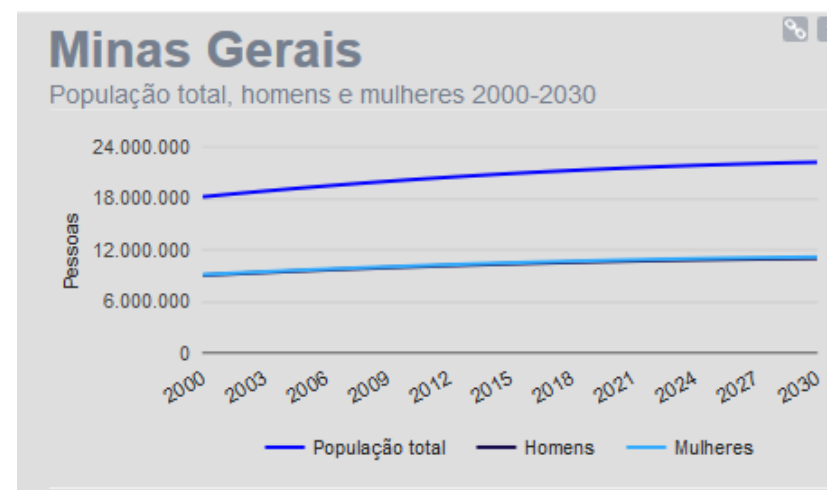
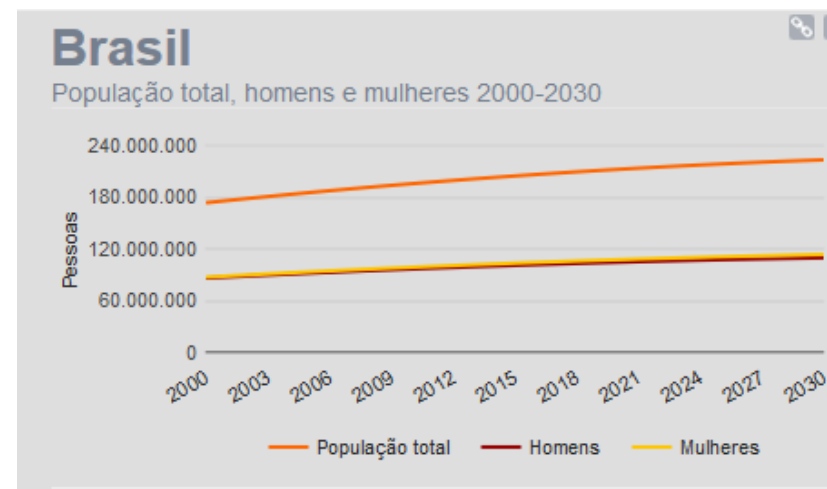


Imag 7- Types of renewable Energy
 Available at <https://epoca.globo.com/colunas-e-blogs/blog-do-planeta/noticia/2016/04/energia-eolica-decola-no-brasil-solar-continua-engatinhando.html> Accessed 10 Jan 2018

HDI- Human Development Index



Imag 8 HDI
 Available at <http://www.revistacobertura.com.br/2017/03/22/idh-brasileiro-para-de-avancar-e-pais-mantem-79a-posicao-em-ranking/> Accessed 10 Jan 2018



Imag 9 e 10 Numbers of the population
 Available at <https://ww2.ibge.gov.br/apps/populacao/projecao/> Accessed 10 Jan 2018

3.2. Minas Gerais

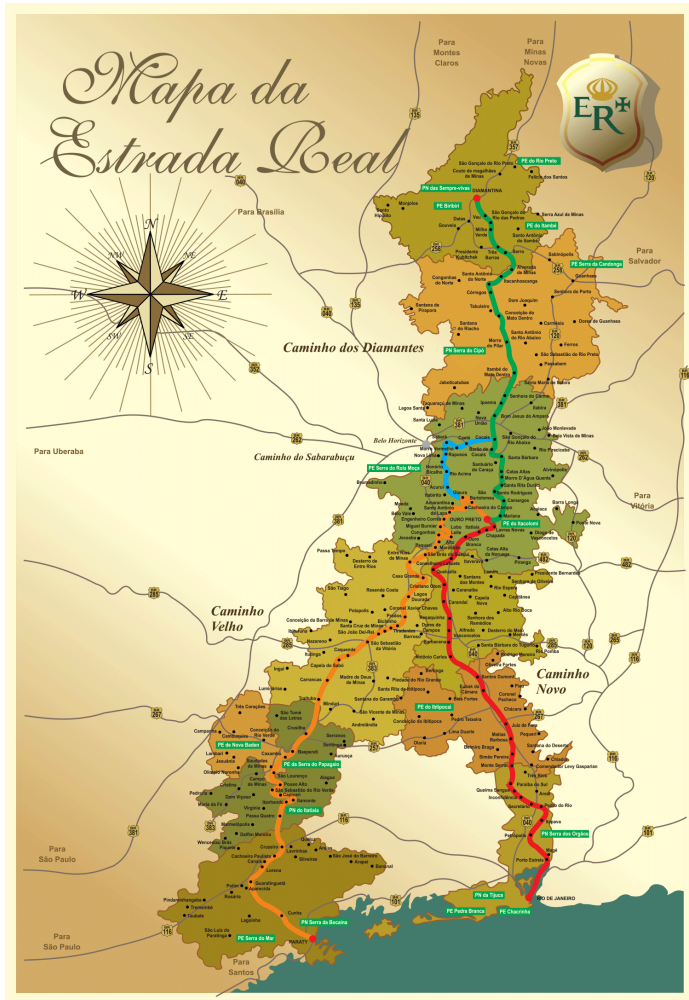
Minas Gerais is located in southeastern Brazil. It has one of the highest gross domestic products (GDP) in the country. The capital is Belo Horizonte. The state is the most top producer of agricultural and mining goods (or commodities) in the country.

The state is famous for its colonial urban heritage, unique Baroque art, particular hilly landscape with waterfalls, caves, and hydromineral vacation resort cities and towns. Minas Gerais has a remarkable scene, characterized by series of mountains and valleys.

Minas Gerais was occupied when the colonizers decided to explore the interior of the country in search of gold and gemstones. In that time many villages were founded. In 1697, with slavery of Africans, the extraction of minerals raised fast, and the Royal route was built.

This path connects the minerals cities to the ports of Rio de Janeiro and Paraty to export to Portugal. All the gold extracted in the country had to be sent to Portugal since Brazil was a colony of Portugal.

The principal cities in that time were Mariana, Ouro Preto, Diamantina, Sabará, Tiradentes, Diamantina and São João Del Rei. The exploration of minerals was so notable that Ouro Preto (old Vila Rica) it was the largest city in Brazil in the 18th century.



Img. 11 Royal Route
 Available at: <https://deboapelomundo.wordpress.com/2015/09/30/pe-la-estrada-real-por-viviane/>
 Accessed: 10 January 2018



Img.12 Location of Minas Gerais
 Available at https://en.wikipedia.org/wiki/Minas_Gerais
 Accessed 10 Jan 2018



Img. 13 City of Ouro Preto
Available at https://www.em.com.br/app/noticia/gerais/2018/09/22/interna_gerais,990804/aplicativo-vai-alertar-sobre-areas-de-riscos-em-ouro-preto.shtml Accessed 11 Jan 2018



Img. 14 Mountains in the region
Available at https://pt.wikipedia.org/wiki/Ficheiro:Montanhas_da_Serra_da_mantiqueira.jpg Accessed 11 Jan 2018



Img. 15 Inside Colonial church
Available at http://portal.iphan.gov.br/uploads/ckfinder/images/Diversas/MG_Ouro_Preto/13_Igreja_NS.jpg
Accessed 11 Jan 2018



Img. 16 City of Belo Horizonte
Available at https://fr.wikipedia.org/wiki/R%C3%A9gion_m%C3%A9ropolitaine_de_Belo_Horizonte Accessed 12 Jan 2018

3.3 History of Mining in Minas Gerais

Mining is a significant economic activity in Brazil which has attracted foreign investors since the colonial times. In that time the extraction of minerals was responsible for the settlement towards inland in the country. Minas Gerais is the most crucial state in Brazil where it is possible to find valuable metals (gold, silver) and valuable gemstones(diamonds, sapphire, amethyst). The mining in Brazil represents 5% of GDP. Minas Gerais is the most critical state for the extraction of the minerals(gold, aluminum, iron, etc.) and valuable gemstones(emerald, topaz, aquamarine, amethyst, etc.) in the country and the world. Mining is the most important generator of employees because almost the industries use minerals for production of materials, and products. Mining has a direct relationship with the sectors then it is the most important generator of jobs.

Impacts of the mining industry

- The effects of the mining industry are several in the environment and health:
- Taking out the vegetation in the mining area
- Pollution of water(in the surface and the ground) with chemical products
- Contamination of the rivers because of improper disposal of unused materials(rocks, minerals, and damaged equipment).
- Noise pollution with heavy machinery



Img. 17 Mining

Available at https://www.avaaz.org/po/community_petitions/Paralisacao_imediata_do_empredimento_Anglo_Ferrous_MinasRio_Minerao_SA_em_Minas_Gerais/ Accessed 11 Jan 2018



Img. 18 Mining in 1800

Available at <http://mineracaoimg.blogspot.com/2011/12/historia-da-mineracao.html> Accessed 11 Jan 2018

4. Mariana

Mariana is the most significant urban center close to the old Bento Rodrigues, and it is distant only 35 km and the new one just 8 km. It has 58 thousand inhabitants. The local economy is tourism and the mining. The mining extracts pit of iron, gold, manganese, quartzite, bauxite. The leading companies such as Samarco Mining and Vale Mining extract iron ores and iron- manganese, they offer a lot of jobs and collect a high percentage of taxes. Mariana has an excellent infrastructure: hospitals, universities such as the Federal University of Ouro Preto(UFOP) and high schools. UFOP offers many courses graduation, masters, PhDs and it has around 2500 students.

Mariana is famous of heritage, the colonial architecture and the Baroque art present in the churches. The tourism includes also visiting the surroundings like the waterfalls, beautiful landscape and the district of Passagem de Mariana, where it is possible to visit a gold mine.

The population of Mariana increased in the 70's with the implementation of Samarco Mining and Samitri mining, and it continued after in the 80's with the arrival Vale Mining company.

Mariana has a high GDP(Gross Domestic Product), it is in 5th position ranking in Minas Gerais and 30th in Brazil. 95% of taxes in Mariana comes from minings, so after the disaster in 2015, the tax revenue was meager.

Chart of Evolution of GDP

Year	PDP (R\$ bi)
2010	3,697
2011	5,729
2012	5,373
2013	6,590



Img. 19 Mariana
Source:Own Private Collection



Img. 20 Streets in Mariana
Source:Own Private Collection

5. SAMARCO

Samarco Mining is a joint venture between Vale Mining and BHP Billiton, and it is the first industry of iron ores in the world and the second mining in the world. The primary product of the company is iron ores. It has three mines in Germano, Minas Gerais and four industries of iron ores. The company extracts iron ores in Germano(place between Mariana and Ouro Preto), with the proximity of 3,3 bi of iron ores. The extraction is open air.

Samarco sells iron ores for 19 countries, in Europe, in Americas, in Asia, and in the Middle East. (SAMARCO, 2014). Since the production is high, the company generate a significant amount of waste (sand and mud) because of the process of iron ore. This waste stays in 3 dams: Germano, Fundação e Cava do Germano. The water used is treated and kept in Santarem dam.

Year	Mining waste (min, ton.)
2010	16,358
2011	15,656
2012	16,694
2013	16,542
2014	21,978

6. Bento Rodrigues

Bento Rodrigues is a subdistrict of Santa Rita Durão which is a district of Mariana), located in the state of Minas Gerais, Brazil. It is 35 km distant from Mariana and 124 km from Belo Horizonte, the capital of Minas Gerais.

6.1 Disaster

In 5th November 2015, the Fundão dam collapsed and destroyed the district of Bento Rodrigues. As said before, the production of iron ores increased, and it was necessary lifting the height of Fundão dam to keep more mining waste. Bento Rodrigues is located in 704m altitude, and the Fundão dam has initially been in 830m, after the extension of the height of 90m, it will be in 940m elevation, however, this process had no success, and the dam collapsed.



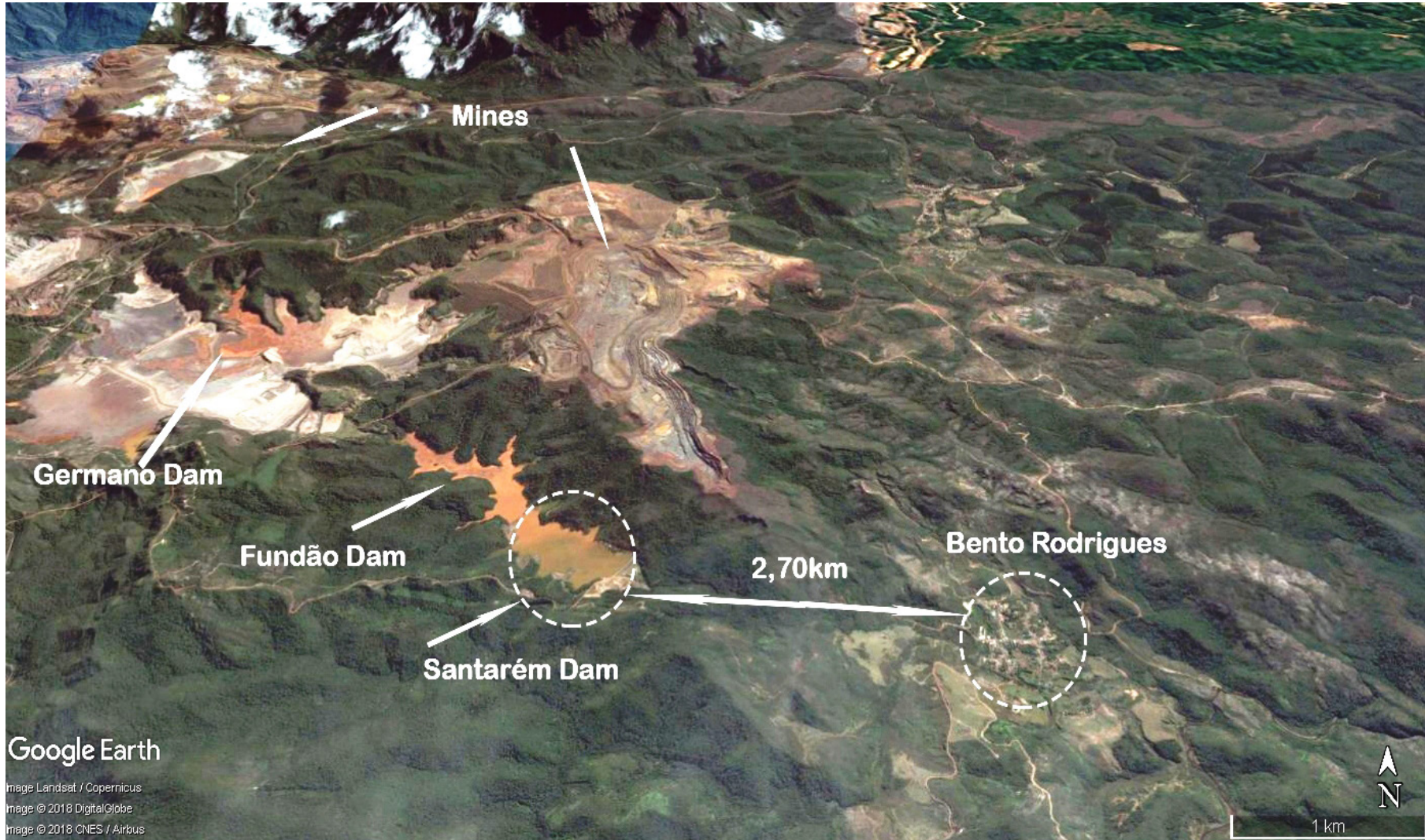
Img. 21 Location of Bento Rodrigues
Available at http://blogpaulomascarenhas.blogspot.com/2015_11_01_archive.html Accessed 12 Jan 2018



Img. 22 Photo of Disaster

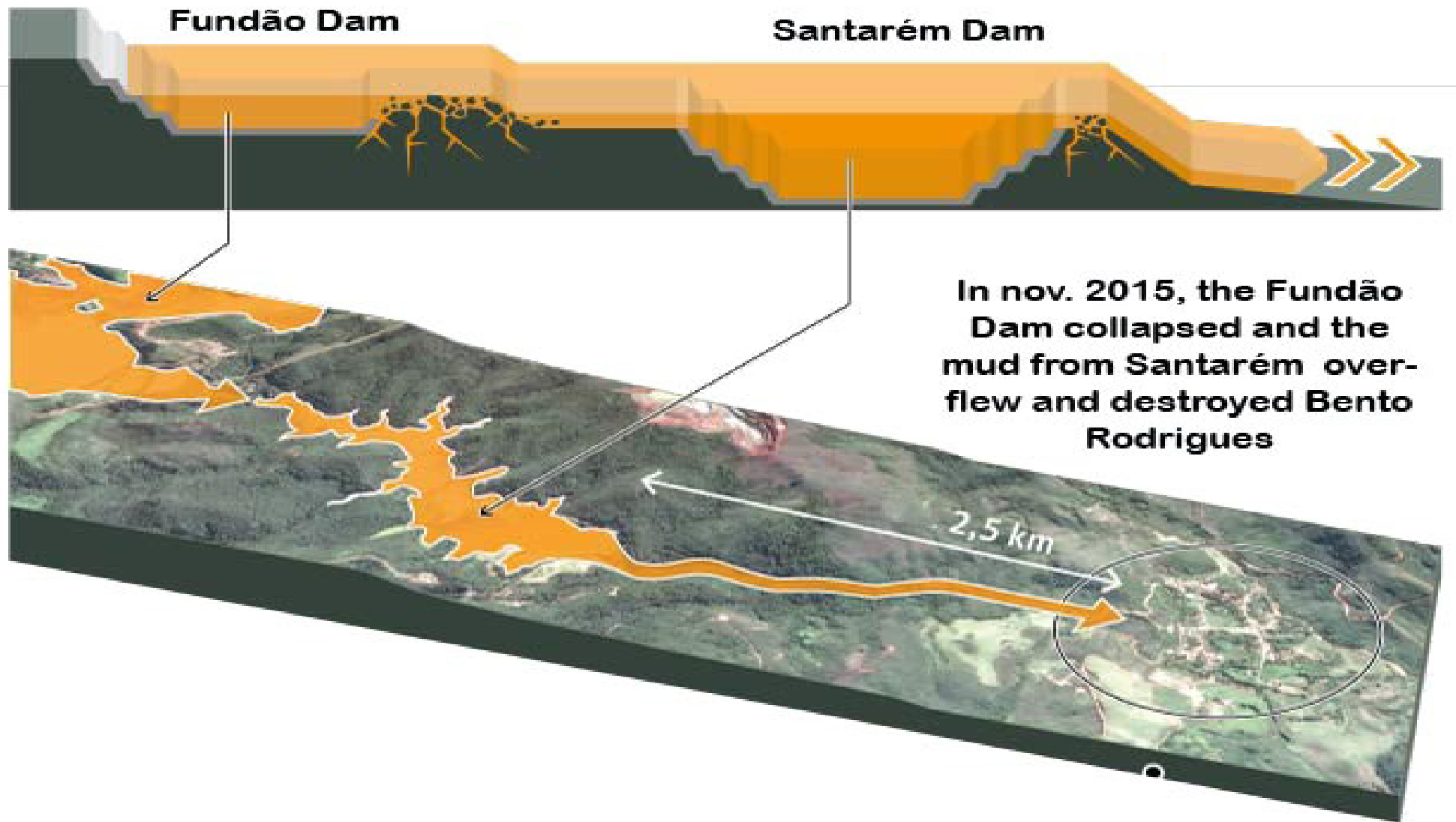
Available at <http://agenciabrasil.ebc.com.br/geral/noticia/2019-11/mariana-ve-melhora-economica-e-aguarda-samarco-apos-4-anos-da-tragedia>

Accessed 12 Jan 2018



Img. 23 Diagram 1 of the disaster

Available at: <https://www1.folha.uol.com.br/paywall/signup.shtml?https://www1.folha.uol.com.br/cotidiano/2016/01/1730239-engenheiro-que-projetou-barragem-diz-que-alertou-samarco-sobre-risco.shtml>. Accessed 20 January 2018



Img. 24 Diagram 2 of the disaster
Available at: <https://www1.folha.uol.com.br/paywall/signup.shtml?https://www1.folha.uol.com.br/cotidiano/2016/01/1730239-engenheiro-que-projetou-barragem-diz-que-alertou-samarco-sobre-risco.shtml>. Accessed 20 January 2018



Img. 25 Church Nossa Senhora das Mercês

Available at <http://www.rainhamaria.com.br/Pagina/18767/Depois-da-onda-de-lama-que-arrasou-o-subdistrito-de-Bento-Rodrigues-MG-cenario-da-localidade-lembra-o-de-um-filme-apocalptico> Accessed 12 Jan 2018



Img. 27 Fauna and flora devastated

Available at <http://www.amafreguesia.org/a-amaf-age-localmente-freguesia-rio-rj-mas-pensa-globalmente-bento-rodrigues-mariana-mg/> Accessed 12 Jan 2018



Img. 26 Image of the disaster

Available at: <https://www.dw.com/en/clearer-picture-emerging-over-brazils-mining-disaster/a-19006554> Accessed:10 Jan 2018



Img. 28 Image of the disaster

Available at <https://domtotal.com/noticia/962646/2015/11/mariana-temor-de-ruptura-de-nova-barragem-forca-retirada-de-moradores/> Accessed 12 Jan 2018



Img. 29 Bento Rodrigues in 2015
Available at <https://www.google.com.br/earth/> Accessed 12 Jan 2018



Img. 30 Bento Rodrigues in 2017
Available at <https://www.google.com.br/earth/> Accessed 12 Jan 2018

The problems related the mining related by the residents

Pollution of the water	Collapsed of dams	Dust	Change the culture	Possibility of expropriation
94%	68%	64%	66%	64%

According to IBAMA(Institute responsible for Brazilian fauna and flora), Fundão Dam had 50mi m³ of mining waste and the leak of 34 mi of this waste in the environment. The first moment, the mud arrived in Santarém dam(water tank), and it went to Gualaxo Norte river until reached in Carmo River and finalized in River Doce. The dirt continued until the Atlantic Ocean in 21st November 2015. Mud covered the city, a river flooded and all the mud arrived until the Atlantic Ocean.



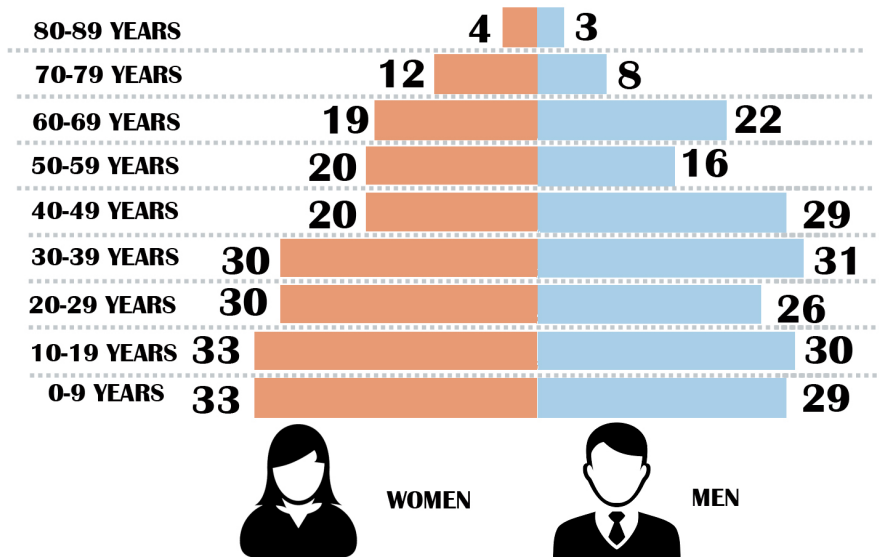
Img. 31 Diagram of the disaster in the country
 Available at <https://www.theguardian.com/sustainable-business/2015/nov/25/brazils-mining-tragedy-dam-preventable-disaster-samarco-vale-bhp-billiton> Accessed 10 Jan 2018

6.2 The damages:

- 20 people died
- Bento Rodrigues was devastated
- many communities were affected by the mud(Paracatu de Baixo, Paracatu de Cima, Águas Claras, Campinas, Borba, Pedras, Bica, Gesteira, Barra Longa)
- indigene community (Krenak, in Resplendor, Minas Gerais) affected in fishing and other uses with water
- more than 600 refugees
- economic impacts in Mariana and Ouro Preto(low revenue of taxes)
- unemployment
- huge environmental effects
- many cities stayed without potable water
- lost of Heritage buildings
- more than 2t of fish died
- heavy materials contaminate the soil
- undrinkable water

7. The profile of population

The profile of Bento Rodrigues includes housewives, students, works and retired people. The streets are an extension of the houses and where social life happens. This village has in the same time urban and rural aspects since one of the transports are horses.



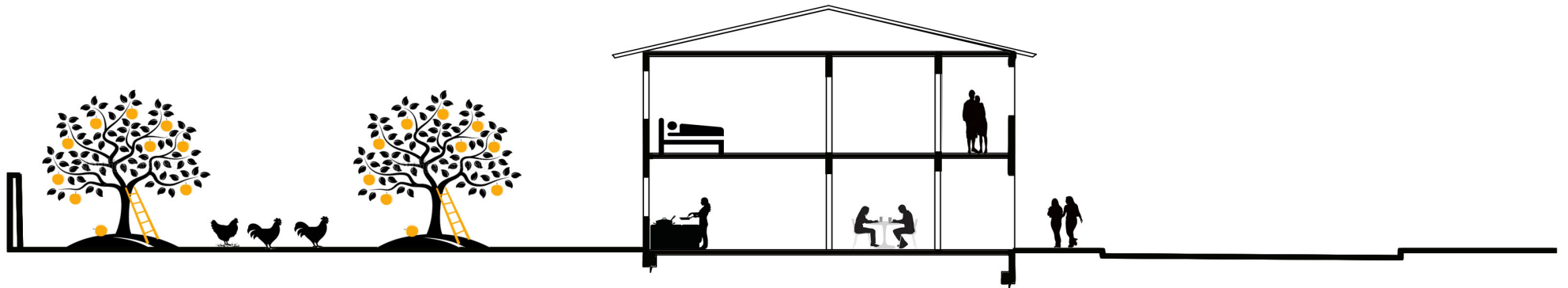
Img. 32 Profile of the population
Own private collection



Img. 33 Social life in the streets
Available at Available at <https://www.google.com.br/earth/> Accessed 12 Jan 2018

7.1 Style of living

In Bento Rodrigues, many architectural forms are found. Since the village was founded in 1697 the presence of colonial style is remarkable although also new constructions are also part of the local architecture. Some elements such as the front porch, terrace, buildings on the street alignment are prevalent in the village



Img. 34 Section of the style of living
Own private collection

Terrace



Colonial Architecture



Front Forch



Under Construction



Far from the street alignment



Img. 35,36,37,38 Images of the style of the architecture
Available at <https://www.google.com.br/earth/> Accessed 10 Jan 2018

Since the village was destroyed, all the residents are relocated to live in Mariana in rent houses or hotels. The company in charge of the reconstruction decided to make all the process together with the locals. So, the first step is to survey to understand how was the village and what they want for a new place. The survey is in the annex 1,2,3, 4.

The program

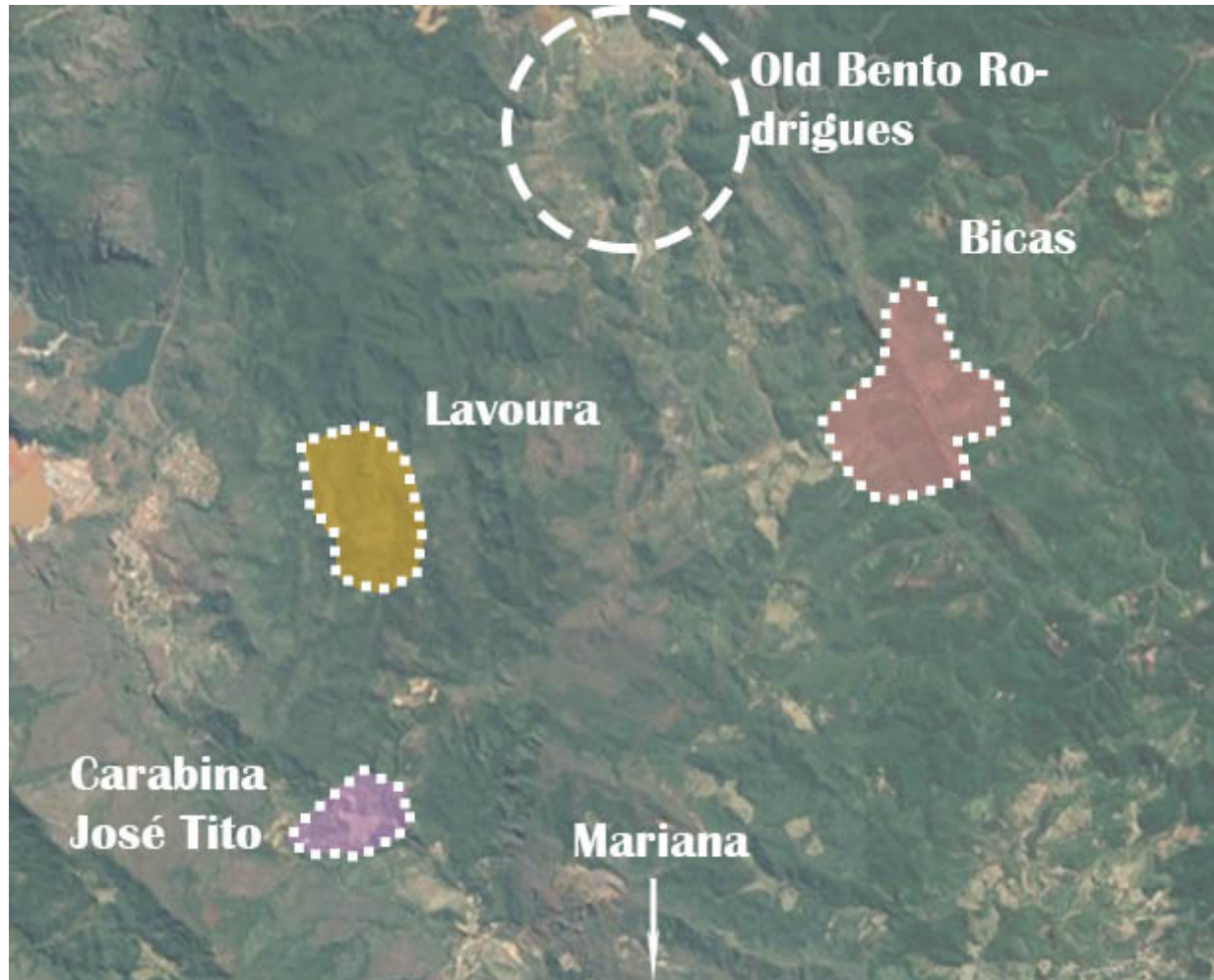
- 200 houses
- Health Center
- Keep the 4 churches
- Elementary School
- Building for Resident's Association
- Soccer field
- Park
- Police Station



Img. 39 Diagram of the needs
Own private collection

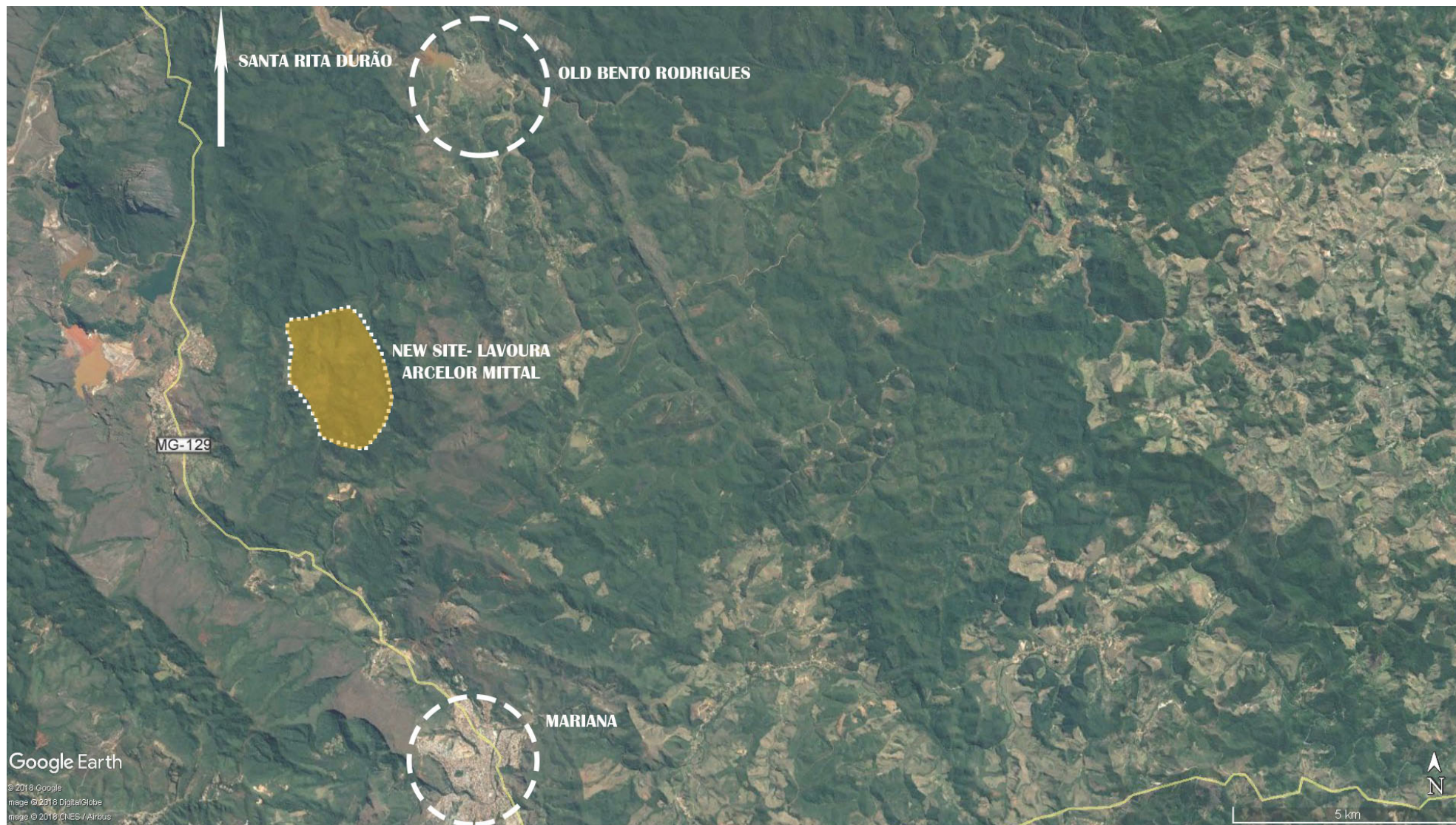
7.2 New location for Bento Rodrigues

The company in charge, Samarco offered 3 sites for the construction Lavoura, Carabina José Tito and Bicas.



Img. 40 Diagram of the options for new site
Own private collection

In November 2017 the assembly with the locals voted Lavoura site to be the new location for new Bento Rodrigues



Img. 41 Location of the new site
Own private collection

7.3 The reasons why Lavoura site was chosen



WATER

Clean water with no contamination



SOIL

Good soil for agriculture and raise animals



SITE

Approved by 90% of the locals



DISTANCE

Far away only 8 km from Mariana

Img. 42 The reasons to take this new area
Own private collection



Img. 43 Assembly to vote the new site
Available at <https://g1.globo.com/minas-gerais/desastre-ambiental-em-mariana/noticia/atingidos-por-rompimento-de-fundao-votam-etapa-de-projeto-para-reconstruir-bento-rodrigues.ghtml> Accessed 11 Jan 2018



Img. 44 Assembly to vote the new site
Available at <https://g1.globo.com/minas-gerais/desastre-ambiental-em-mariana/noticia/atingidos-por-rompimento-de-fundao-votam-etapa-de-projeto-para-reconstruir-bento-rodrigues.ghtml> Accessed 11 Jan 2018



Img. 45 The new site
Source: Own private collection



Img. 46 The new site
Source: Own private collection



Img. 47 The new site

Source: Own private collection



Img. 48 The new site

Source: Own private collection

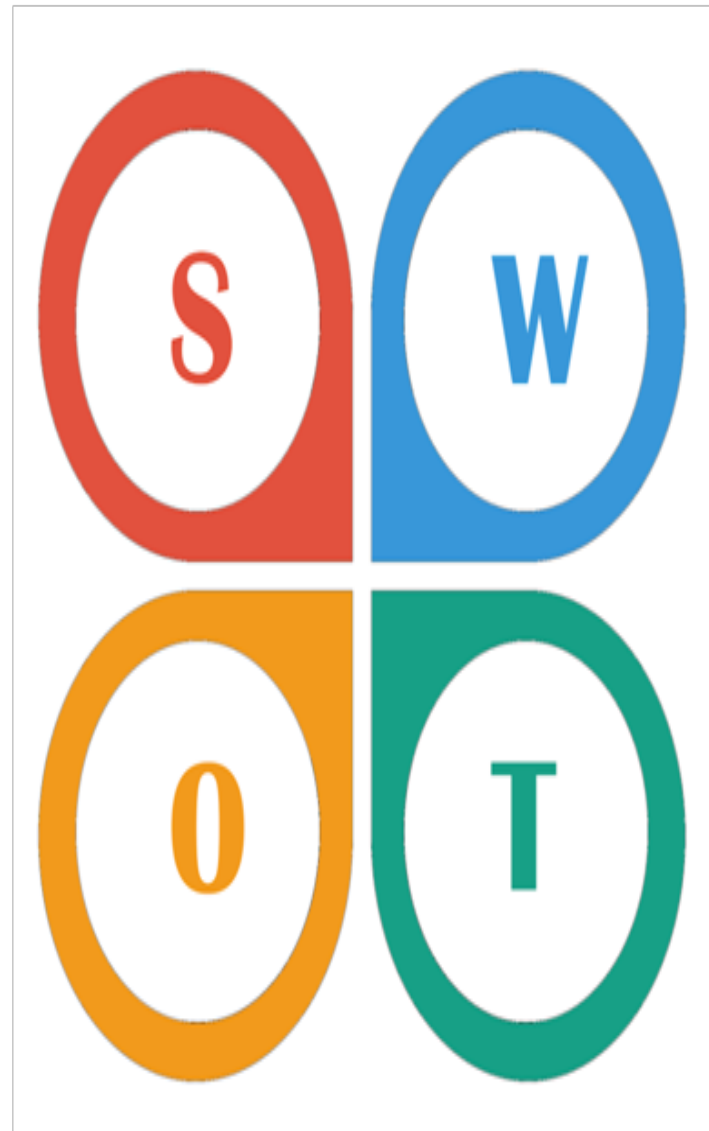
7.4 SWOT

STRENGTHS

- Remarkable landscape
- In due to proximity to Mariana it is possible to use the infrastructures
- Quite and nice place to live

OPPORTUNITIES

- Improve the local economy
- Build the village in sustainable way



WEAKNESS

- Deep topography
- Rebuild the village in a way to keep the identity

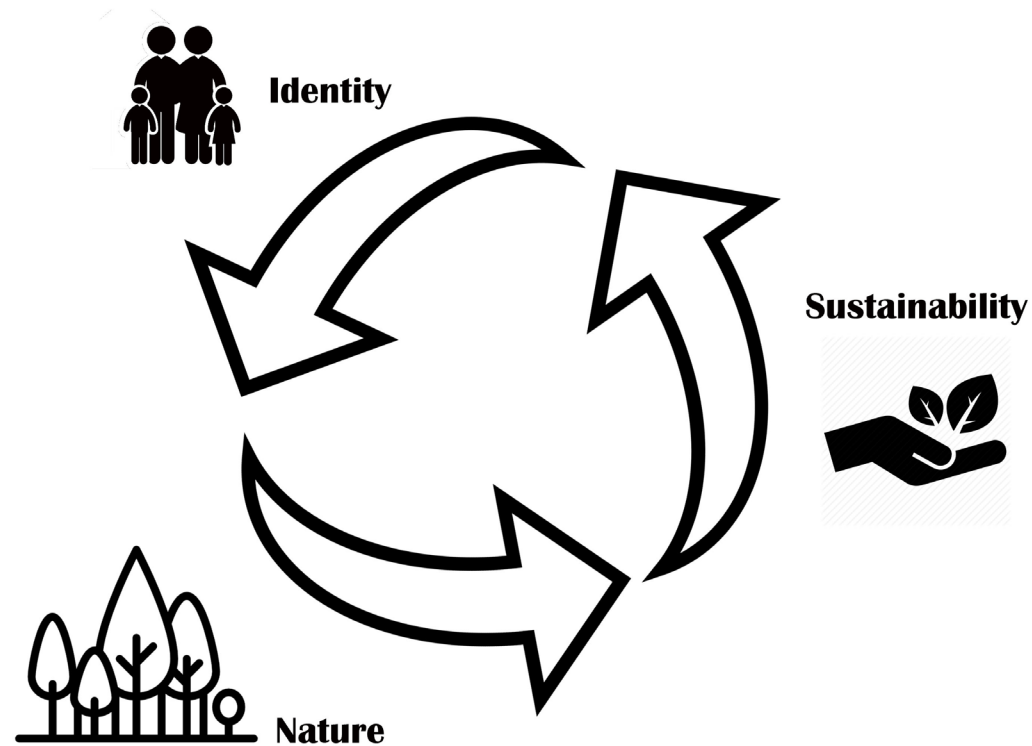
TREATS

- To set up the village in this area can damage the natural landscape
- The village can have densification because of the proximity to Mariana

8. THE PROPOSAL

The thesis seeks to do an urban design for the village Bento Rodrigues in based on three concepts: nature, sustainability, and identity.

The Strategies



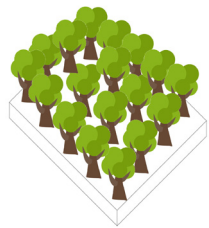
Img. 49 The diagram of the Strategies

Source: Own private collection

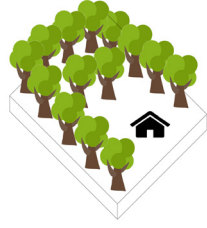
8.1. The nature concept:



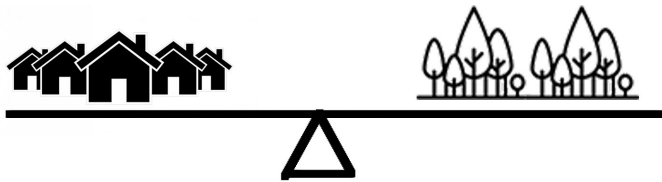
Since the new Bento Rodrigues is close to nature, it is making necessary to understand this relationship. To keep the identity and preserve the environment it is essential to find a balance between landscape and the village. This balance provides more integration with the land and also gives low densification.



Before



After- Low density



Balance between the city and the nature



Activities in the urban park

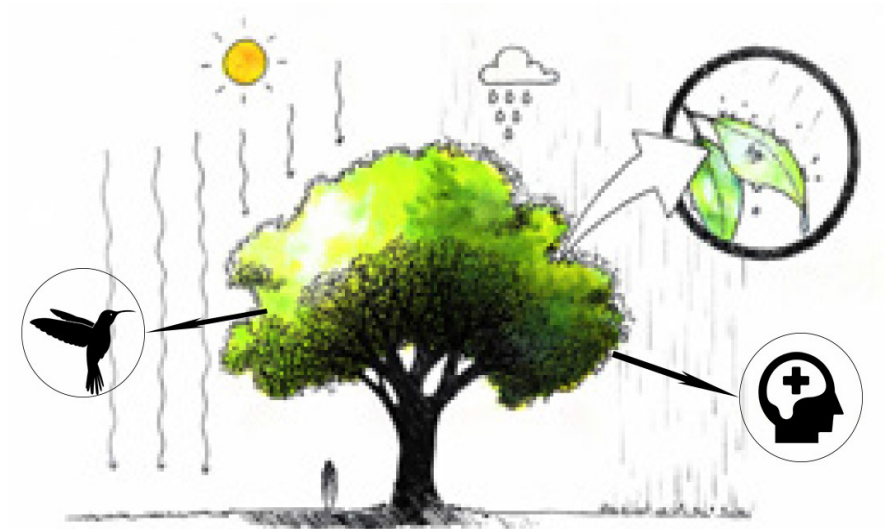
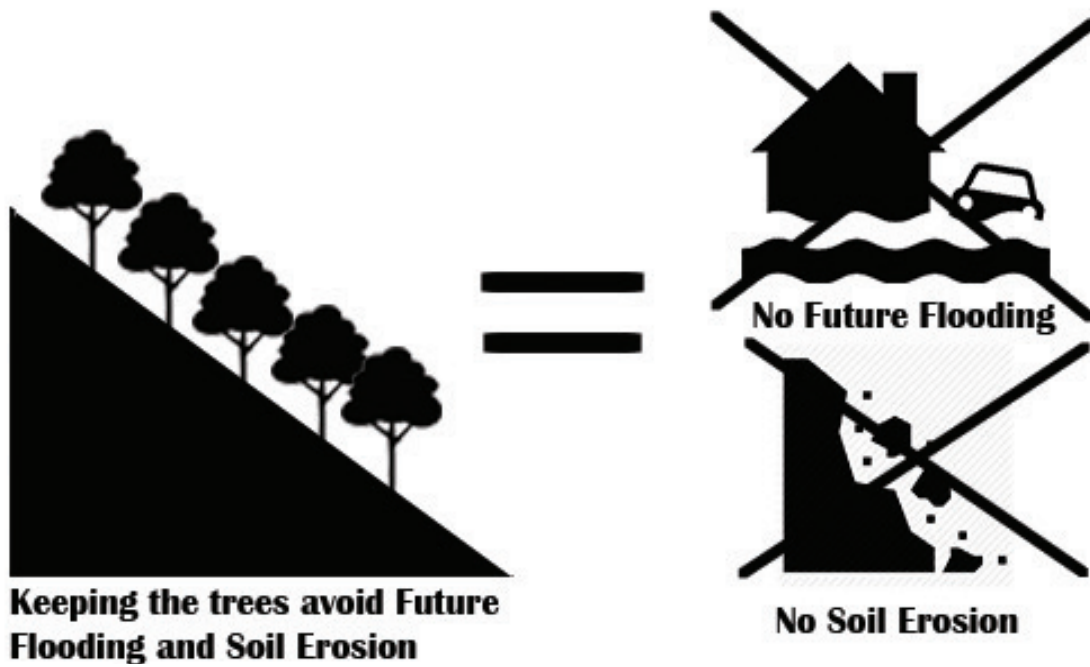


Integration



Bring the nature to be part of the village

The integration seems to be made bringing the nature to be part of the village through an urban park.

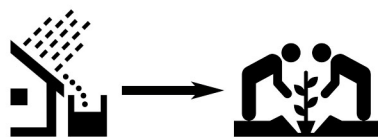


Img. 49 ,50- The diagrams of the reasons to keep the vegetation
 Source: Own private collecton

8.2. Sustainability

The sustainability is to improve the local economy with the urban farming of fruit trees and vegetables to produce some products like jams especially the famous one made with Brazilian Beak Chilli. These activities can generate more jobs that also helps to keep the youth people to live there. Another aspect of the economy should create a small brick factory using the mud of the disaster to rebuild the city with a partnership of the Federal University of Minas Gerais. And also, reuse the rainwater for urban farming.

Reuse the rainwater for urban farming



Img. 51 Image of the familiar urban familiar
Available at <https://www.flickr.com/photos/codevasf/14226386067> Accessed 12 Jan 2018

Increase the local economy



Img. 52 Image of the sweets
Available at: <https://respostas.sebrae.com.br/pesquisa-de-comercio-exterior-sebrae-alimentacao-produto-goiabada/> Accessed 10 Jan 2018



Img. 53 Image of the Jam
Available at <https://www.hojeemdia.com.br/horizontes/produtores-da-geleia-de-pimenta-de-bento-rodrigues-lan%C3%A7am-site-para-venda-do-produto-1.391601> Accessed 10 Jan



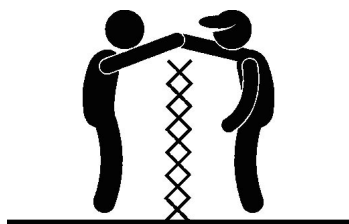
Img54 Image of the brick
Available at <https://casavogue.globo.com/Arquitetura/Cidade/noticia/2016/04/projeto-transforma-lama-de-mariana-em-tijolos-e-reconstrui-casas.html>
Accessed 10 Jan 2018

8.3. Identity:



The reconstruction of the village it is hard to deal because it is necessary to create a new place and at the same time keep the identity of the old place and the people. People have only the memories, and they have to rebuild a new chapter of their lives. In this context, the new typologies should provide this character. The company will provide part of the construction, and the owners will finish the house in the way they think it is more suitable for their necessities. This new part can be a shop, a restaurant, a garage, a terrace or a bedroom.

Keep the neighbours

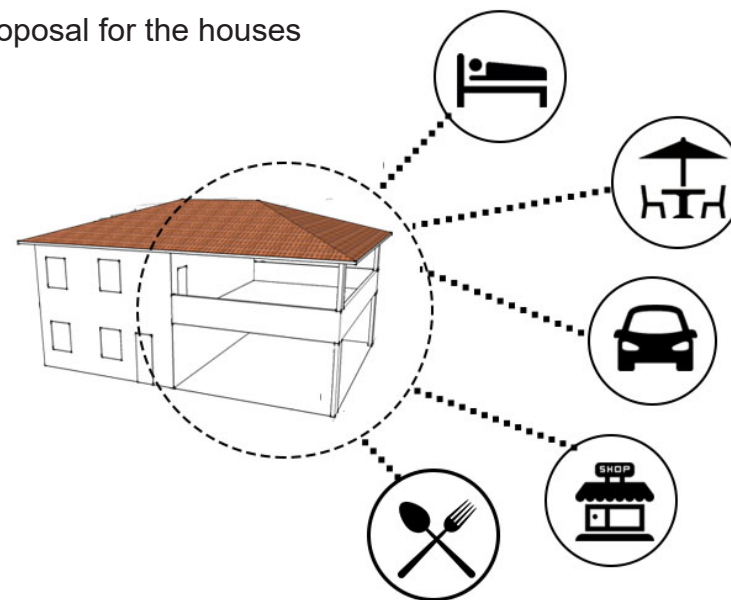


Img. 55 The diagrams of the existed neighbourhood
Source: Own private colleciton



Img. 56 Inpiration for the houses- Elemental Office
Available at <https://www.plataformaarquitectura.cl/cl/02-309072/villa-verde-elemental>
Accessed 10 Jan 2018

The proposal for the houses

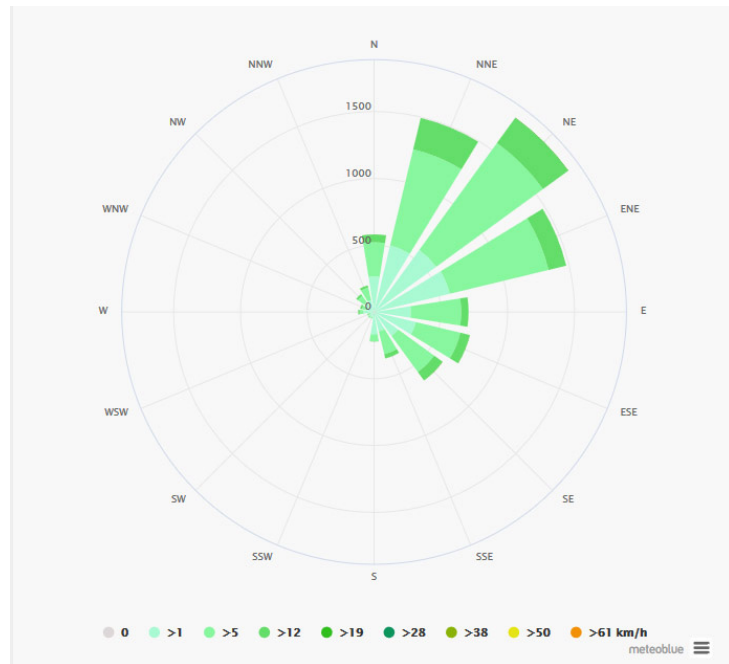
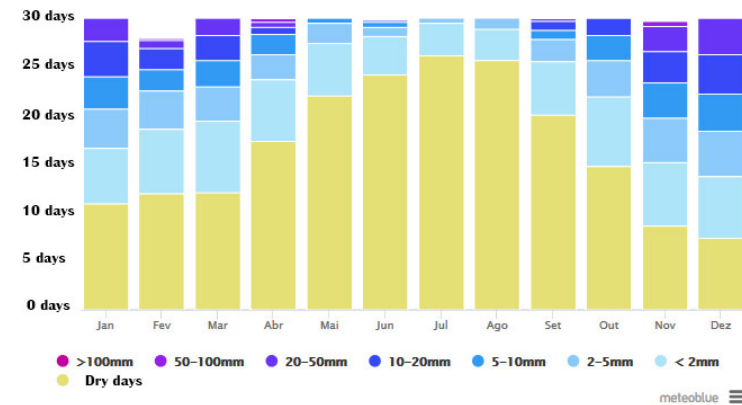


Img. 57 The diagrams of the proposal for the houses
Source: Own private colleciton

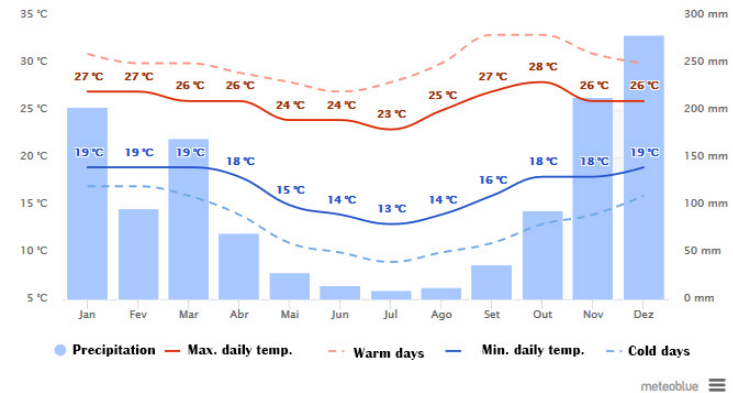
8.4. Analysis of the site:

The climate of Bento Rodrigues has a humid high-altitude tropical climate. From September to April it is considered the rainy season, and from May to August, it is the dry season with low temperature. In that context, collecting rainwater can be an excellent solution for sustainability.

Precipitation



Temperature and precipitation



Img. 58,59,60 Analysis of the Wind, Precipitation and Temperature
 Available at https://www.meteoblue.com/pt/tempo/previsao/modelclimate/mariana_brasil_34357736 Accessed 11 Jan 2018

8.5. Biome

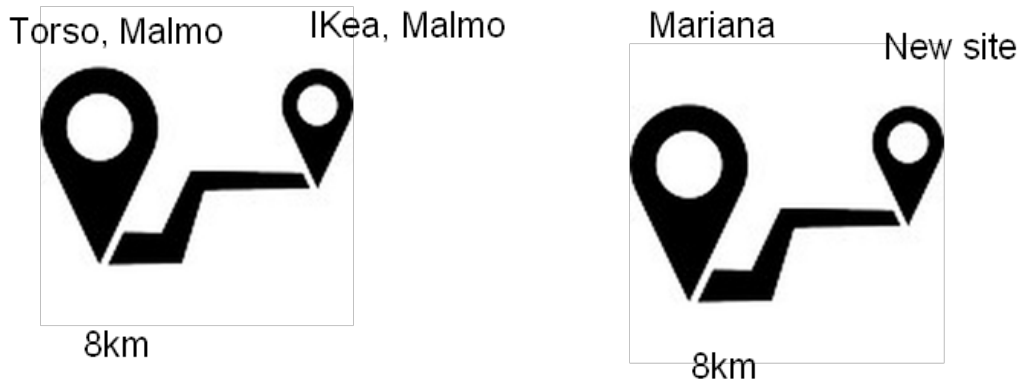
The vegetation is formed by Atlantic Rainforest and The Brazilian savanna.



Img. 61 Image of the tree Ipês
Available at <https://br.pinterest.com/pin/700661654498397338/?lp=true> Accessed 12 Jan 2018

Comparasion distance

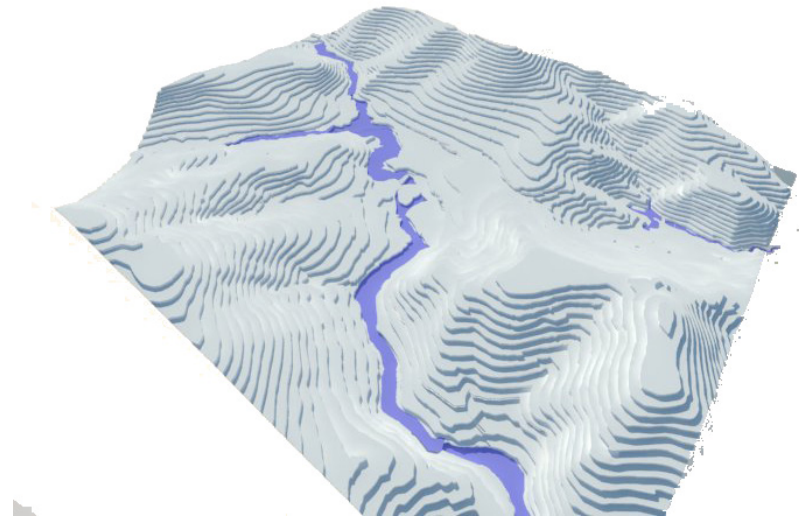
The new site is located only 8 km far away from Mariana. That is a strategical location because people can work in Mariana and live in Bento Rodrigues and they can continue to have a quiet and calm life. This proximity provides the locals the opportunity to use the existing infrastructure in Mariana like universities, hospitals, and high schools.



Img. 62 The diagrams of the proposal for the houses
Source: Own private colleciton

8.6. Physical Analysis

The new site has a steep topography that is a typical topography for the region, and it is a challenged for a reconstruction. The site also has two streams that give some more contact with nature.

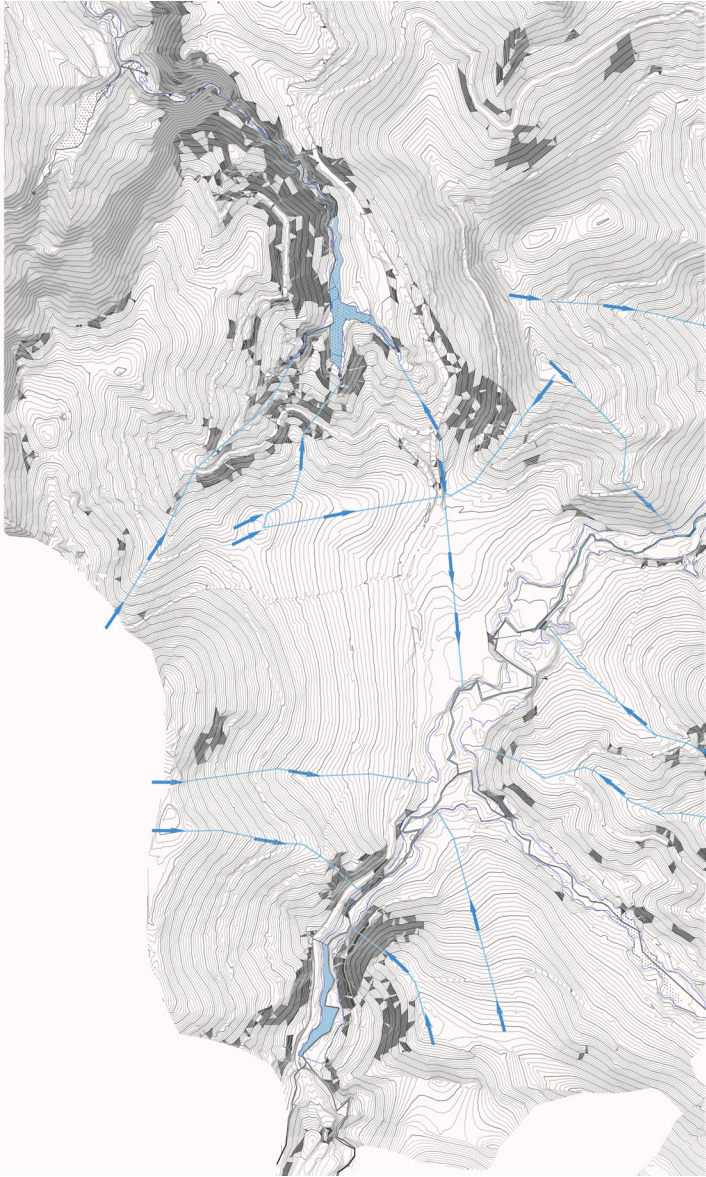


Img. 63 Image of the model
Source: Own private colleciton

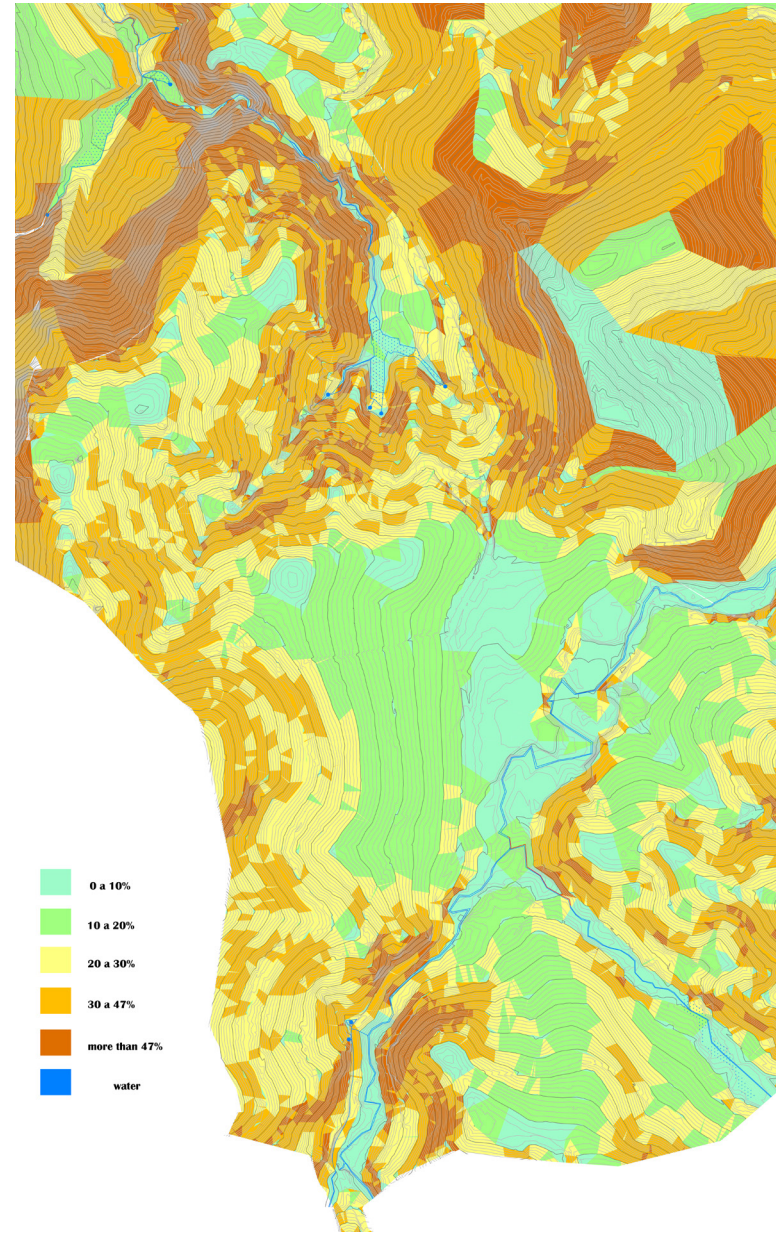


Img. 64 Image of the new place

Available at <https://maisminas.org/projeto-urbanistico-de-bento-rodrigues/> Accessed 11 jan 2018



Img. 65 Image of the water direction
 Source: Own private collection



Img. 66 Analysis of declivity
 Source: Own private collection

8.7. Regulations

In Brazil, there are some regulations to be followed to keep the ventilation, the thermal comfort for the houses, and to protect the nature.

Federal Law 6766- Land subdivision and urbanization

Federal Law 6766- Land subdivision and urbanization

Legal parameters

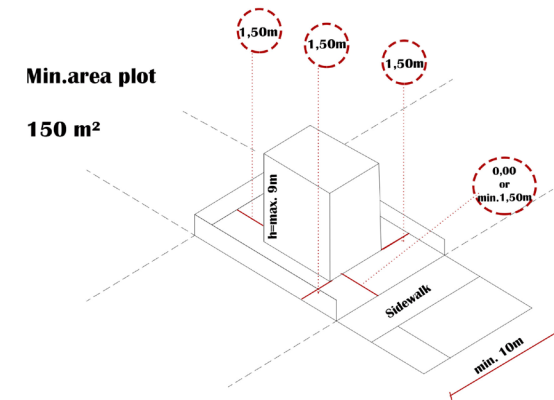
Prohibition

- It is prohibited any construction in places with declivity equal or more than 47%
- It is allowed to build between 30-47% only with topographical surveys and geotechnical studies
- Is not permitted to occupy Environmental Protected area
- It is obligatory leave an empty space far away 30 meters from each side of the rivers, springs, streams. In that area is not allowed to build, it is called “non aedificandi”

Complementary Law 108-2017

Local law (Complementary law 016/2004) Mariana Municipality

- The street should have at least 10 metres
- The blocks have to be less than 200 metres
- The width of the parcel has to be 10 metres
- The minimum area for the parcel(plot) is 250 metres
- All the plots have to exit to the street



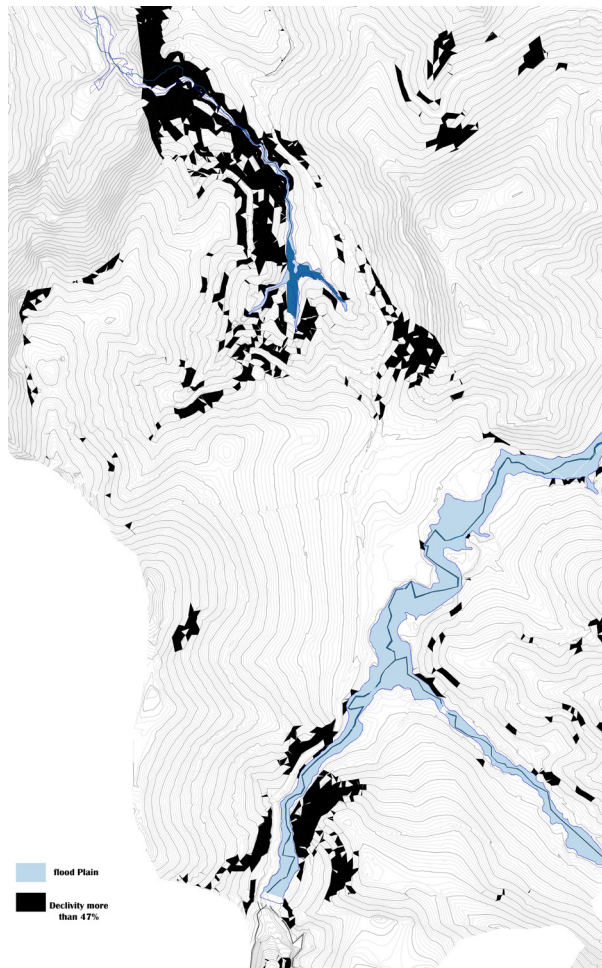
Img. 67 Diagram of distances in the plot
Source: Own private collection

PARAMENTER FOR DIVIDING INTO INSTALLMENTS, USE AND OCCUPATION OF THE PLOT				
PARAMENTER OF PLOT'S SIZE	SIZE OF THE PLOT (m ²)			
	<= 300	300 < x <= 600	600 < x <=	< 1000
MAXIMUM OCCUPATION OF THE PLOT	70%	60%	50%	40%
PEARMIBILITY	15%	20%	25%	40%
MAXIMUM UTILIZATION COEFFICIENT	1,2	1	0,8	Limited in 800,00m ²
HOUSING UNITS PER PLOT	90	120	170	Limited in 6 housing units
MINIMUM FRONT OF THE PLOT	10,00 m	12,00 m	minimum 12,00 m	
HEIGHT	2 storeys			
DISTANCE FROM THE BUILDING OF STREET AND NEIGHBORS				
FRONT DISTANCE	0,0 m or 1,50m (minimum)			
BACK AND LATERAL DISTANCE	1,50 m (min)for height maximum 6,00m			
	1,80 m (min) for height between 6,00 m and 9,00 m			
MINIMUM OF PLOT	150,00 m			

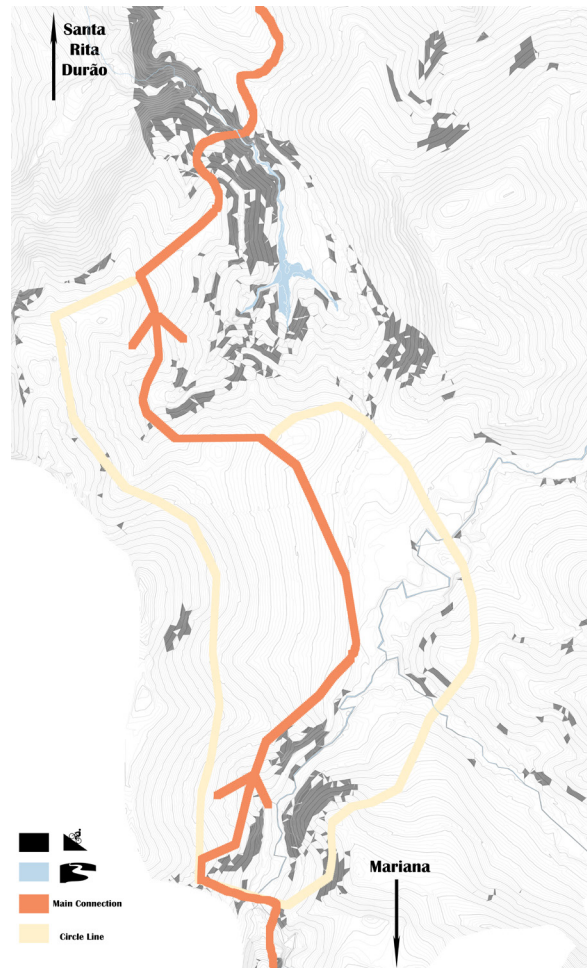
In plots with maixum 300,00m² it will be possible to build close to lateral border if the building has maximum

8.8 The process for the proposal

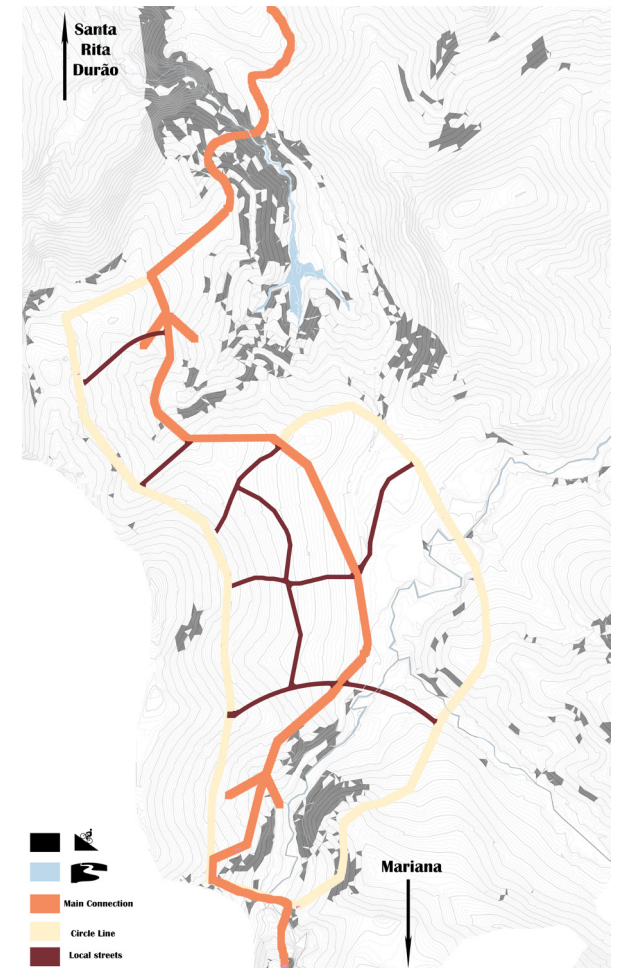
To start a project in a place with this particularly topography it is essential to analyze declivity to check where it is better to build and the natural elements. This site has many areas with inclination more than 47% which it is not allowed to construct. Also, it has two streams that can be used for recreation and be part of the urban landscape. The bank of the streams will be preserved to avoid future floods. The village needs the main street to connect it to Mariana and Santa Rita Durão passing in the middle of the place respecting the declivity. And another connection circulating the area to cover almost the sites.



Img. 68 Analysis of natural elements
Source: Own private collection



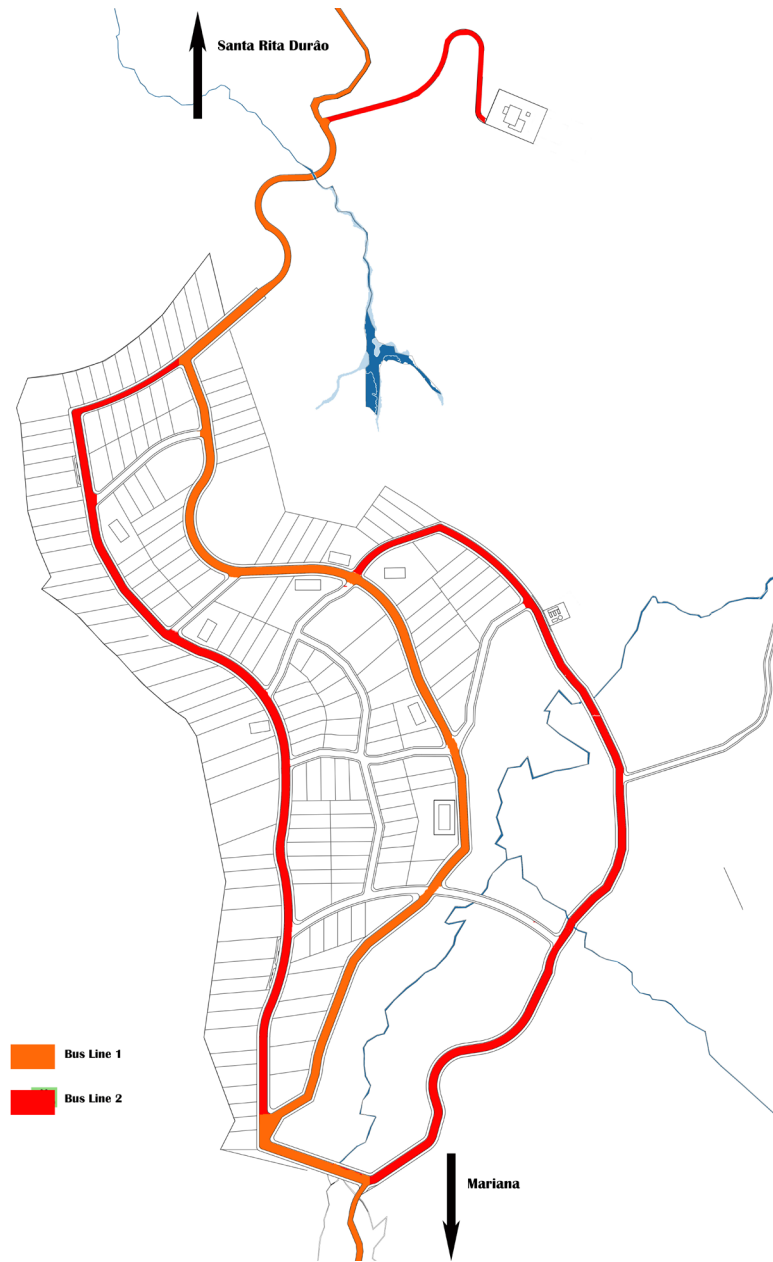
Img. 69 New roads
Source: Own private collection



Img. 70 New roads and the local ones
Source: Own private collection

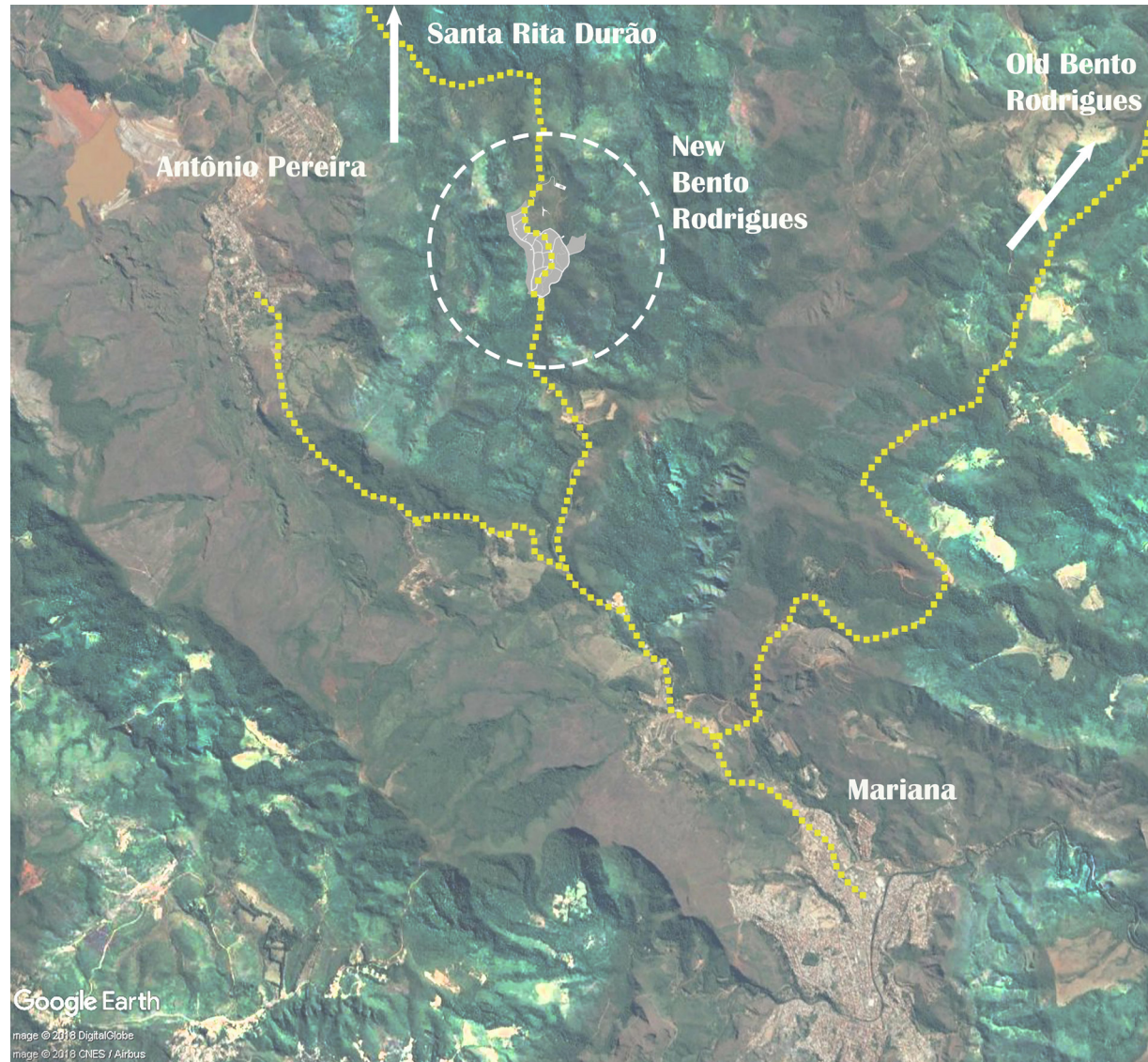


Img. 71 The diagram of the services
Source: Own private collection



Img. 72 The buses lines
Source: Own private collection

Landscape Strategy.



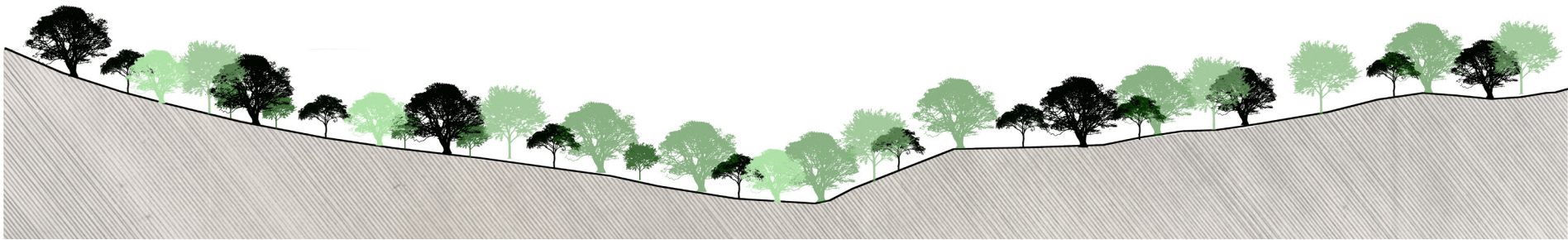
Img. 73 Connections
Source: Own private collection

The new infrastructure respects the requests of the locals and some others are added such as the Police Station, Health center.

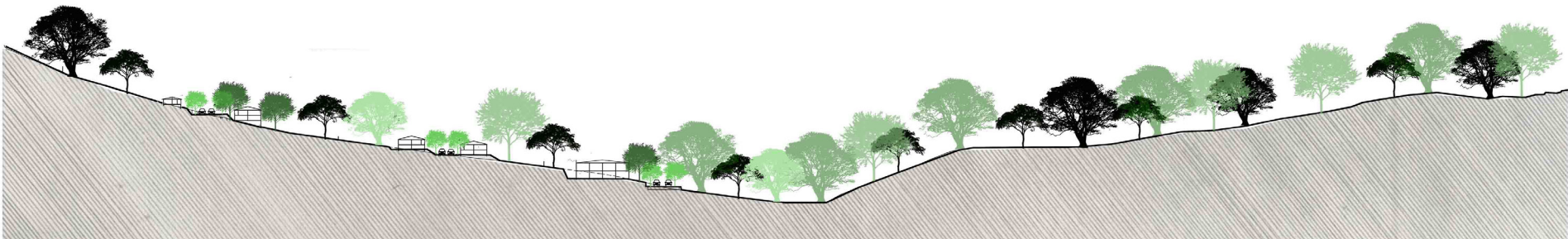
The village needs two buses lines, one to connect the town to Mariana and one local with more frequency.

Relationship with the place

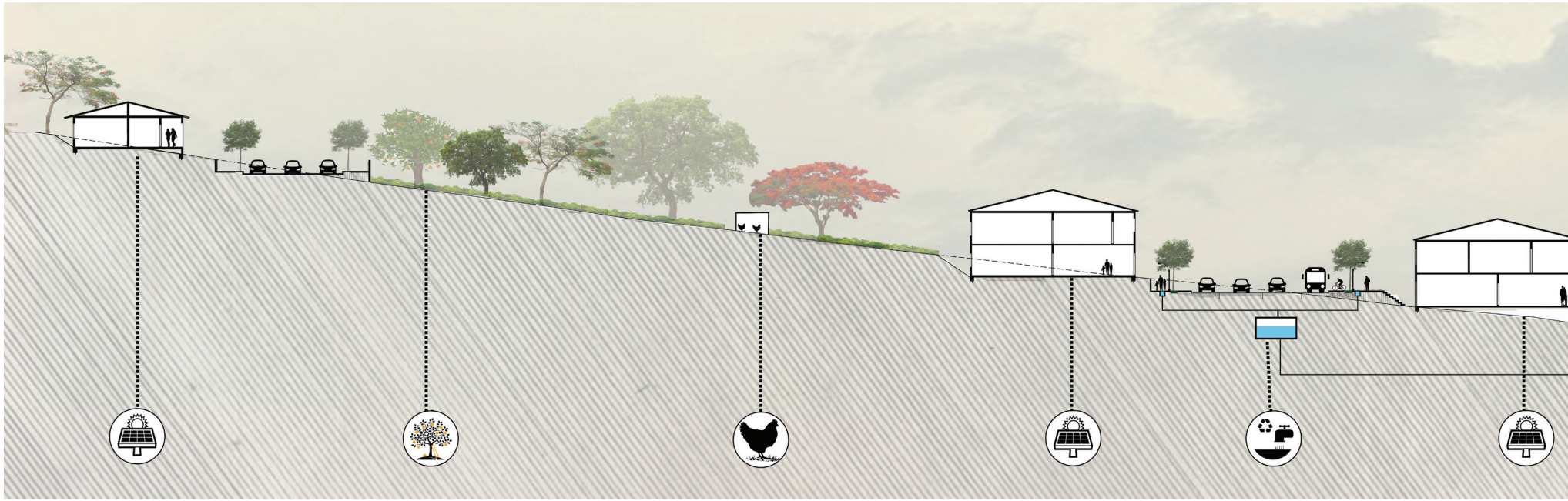
To keep the balance with nature and to have a low densification



Img. 74 The nature before the intervention
Source: Own private collection



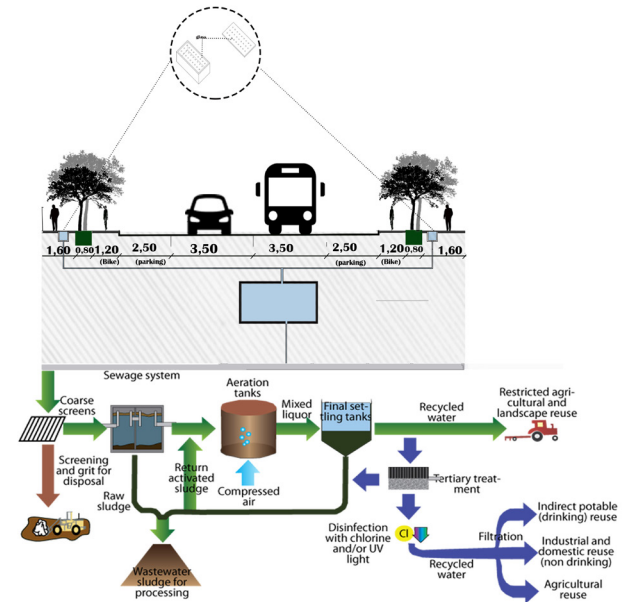
Img. 75 the nature after the intervention
Source: Own private collection



Img. 76 Section BB Section of the city
 Source: Own private collection



Img. 77 Section AA Section of the park
 Source: Own private collection



Conceptual diagram illustrating a modern central collection and wastewater treatment plant, which can remove nutrients from wastewater to very low levels (i.e., tertiary treatment) and provide recycled water for agricultural and landscape uses. Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Kuczyński, W.L. and P.J. Fletcher (eds.). 2012. Tropical Connections: South Florida's marine environment. IAN Press, University of Maryland Center for Environmental Science, Cambridge, Maryland. 492 pp.

Img. 78 Diagram of collection of the rain into the streets
Source: Own private collection



Detail of the street

The main street will have some glass boxes to collect the rainwater to reuse them for the urban farming. These boxes will be part of the landscape.



Img. 79 Image of the main street
Source: Own private collection

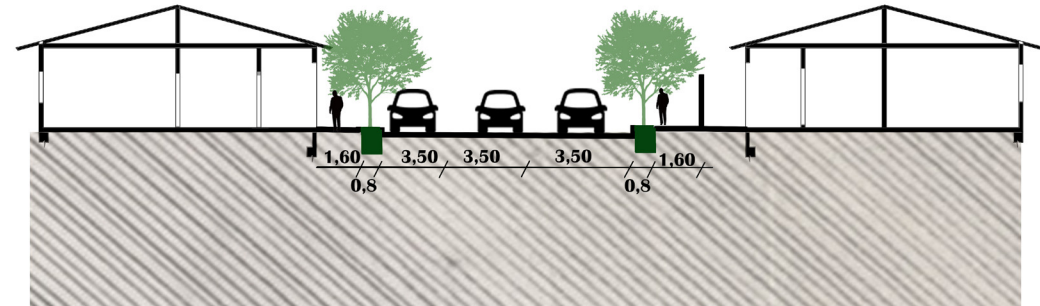


Img. 80 Image of the Church
Source: Own private collection

List of the trees used in sidewalk

	Scientific Name	Popular name	Height	Treetop
1	<i>Bauhinia blakeana</i>	Pata de Vaca	6-8 m	voluptuous
2	<i>Bauhinia variegata</i>	Pata de Vaca	7-10m	voluptuous
3	<i>Handroanthus chrysotrichus</i>	Ipê-Amarelo	4-10m	deciduous
4	<i>Michelia champaca</i>	Magnólia amarela	7-10m	voluptuous

Detail of the street to plant tree



Img. 85 Detail of the streets to plant tree in the streets
Source: Own private collection



Img. 81 *Bauhinia blakana*
Available at https://static.wixstatic.com/media/f8e203_6dd588e7195e4af69db-986164024c8e9~mv2.jpg Accessed 12 Jan 2018



Img. 82 *Bauhinia variegata*
Available at https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcS99n_H4dbU51xY7N_YF4NmYMr-Zs0vBNA58zWu0myXhBV-IH_2&ss Accessed 12 Jan 2018



Img. 83 *Handroanthus chrysotrichus*
Available at http://www.ufrgs.br/fitoecologia/florars/open_sp.php?img=13719 Accessed 12 Jan 2018



Img. 84 *Micheilia champaca*
Available at <https://www.pacifichorticulture.org/wp-content/uploads/2012/04/Ritter.01.champaca-1.jpg> Accessed 12 Jan 2018



Img. 86 Detail of House Plot
Source: Own private collection



Img. 87 Detail of Neighbourhood in the project
Source: Own private collection

8.9. Masterplan



Img. 88 Master Plan

Source: Own private collection

8.10 Detail Plan



Img. 89 Detail Plan
Source: Own private collection



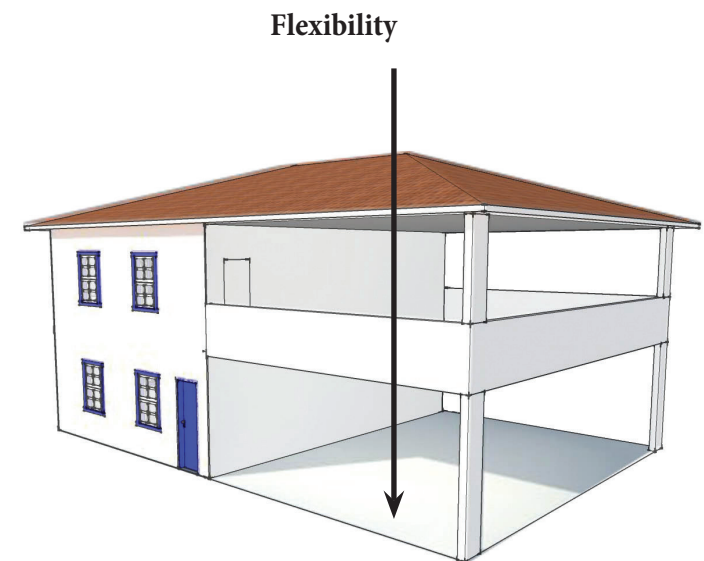
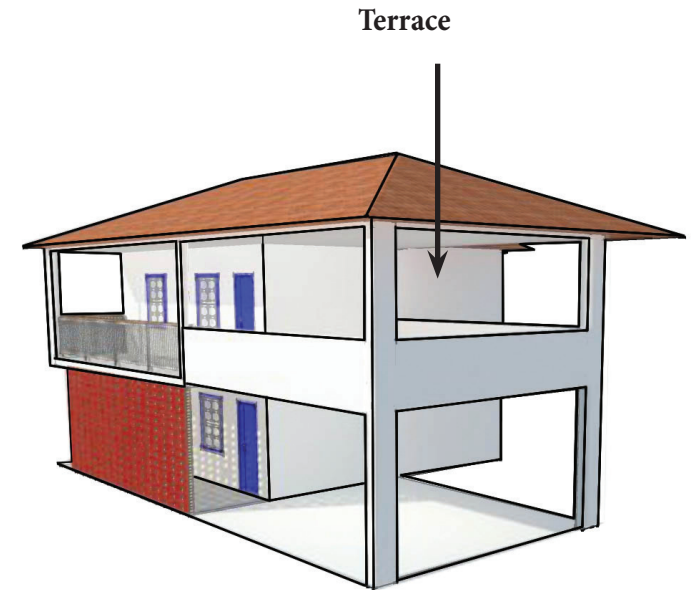
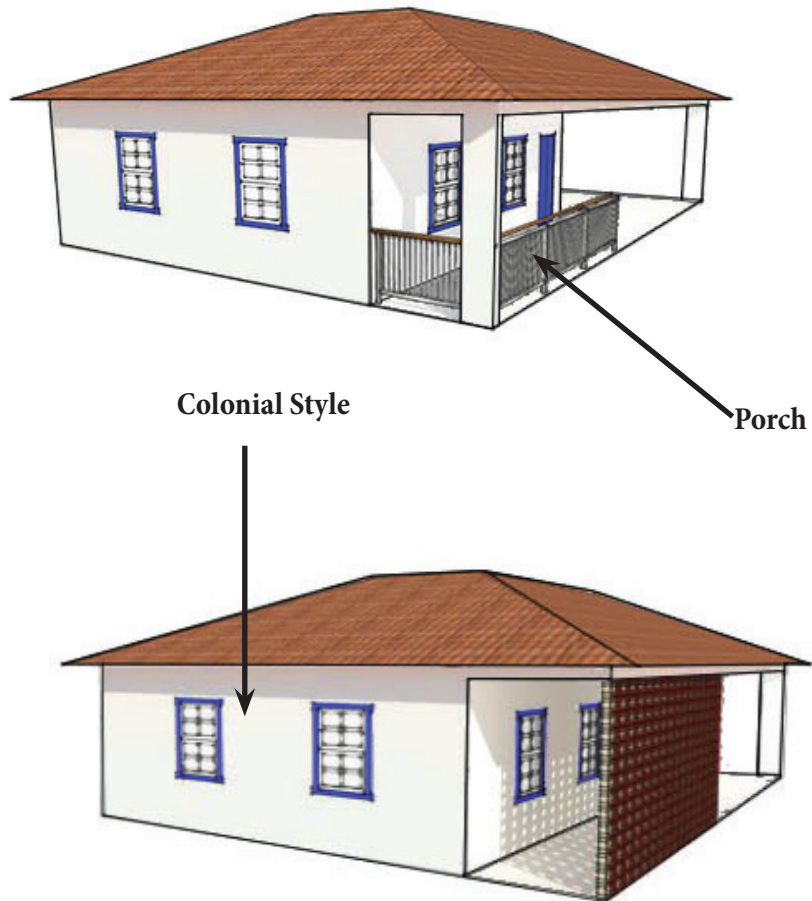
Img. 90 View of the park
Source: Own private collection



Img. 91 View of the park
Source: Own private collection

8.11 Identity in the typologies

The houses developed have some particular design to keep the identity make the locals more part of the process. The home has some colonial elements like the windows and doors with wood and colour frames. The hollow brick wall is a way to protect against the sun such as the front porch. The terrace can be part of the place to make activities.



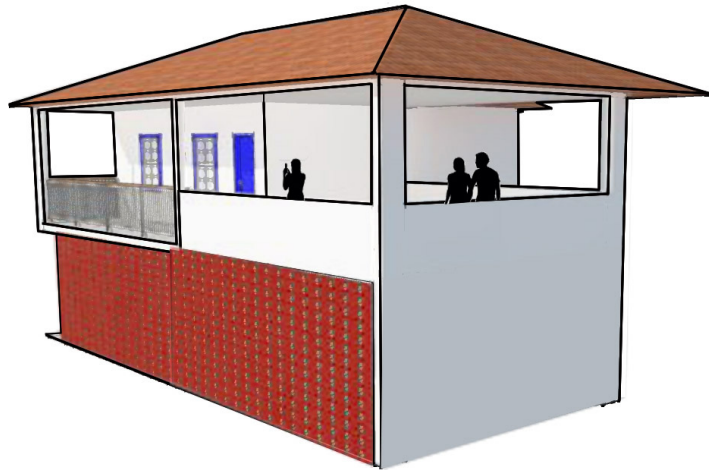
9. Options of flexibility



1- House with a store



3- House with a bar



2- House with an extension of the front porch and terrace



4- House with garage and extension in the 2nd floor

10. Conclusion

An environmental disaster devastated Bento Rodrigues and to make a new plan was a challenge, especially because to create a new village in a different site and keeping the identity is not easy. The original master plan is an area voted by the residents which the occupation has a balance with the nature in the surroundings. The new typologies for housing is a way to keep the identity and a more connection with the place. In conclusion, the residents will have a town where they feel part of it.

11. Annex

CULTURE		
SUBJECT	BEFORE THE DISASTER	WHAT THEY WANT FOR THE CITY
Religious festivities e not religious (which, where they happen and who participate)	<ul style="list-style-type: none"> • Quadrilhas(typical dance) • Soccer and cards turning • Carnival for the kids • Kid's day • A court in the square for the teenagers • Nossa Senhora das Mercês church with the procession and mass • Evangelic meeting in July and in August with other communities • Novena in Easter week, Via Crucis and procession • May: month of Holy Mary with coronation for girls- in São Bento church • June: month of coronation for boys • July: São Bento Festivity with procession, mass • 12th October (Nossa Senhora de Aparecida) visit to the saint's cave • Christmas mass and new year's with presentation • Coffee/ bread to Antonio Saint 	<ul style="list-style-type: none"> • Keep the tradition of the festivities • Reconstruction of Large Cross in highest place in the city • Get a sponsorship to do the festivities • Get back the procession of horses with concerts • Create a gastronomic festival with the traditional food from Bento • Improve the publicity of the festivities • Guarantee the electricity for the events • Construction of community place to do parties • Improve the structure of Small church Nossa Senhora de Aparecida with restrooms • Construction of Soccer Club of Bento, it should be public • Development of touristic rout to visit the Royal Route • Rescue the party in Large Cross in Santa Cruz's day- 3rd May
Social events (which, where they happen and who participates)	<ul style="list-style-type: none"> • Beneficent bingos in São Bento and Nossa Senhora das Mercês festivities • Soccer and card turning • Food and Art craft tents in festivities • Aero Bike turning- part of the turning passes by the city • Touristic point for Royal Route 	<ul style="list-style-type: none"> • Keep the existing social events • More investments for the festivities • Rescue the forró's dance party • Rescue the Epiphany festivity • Construction of the Soccer field • Construction of the place for Association to do social events • Keep the same name for the streets and public buildings
Dance (typical)	<ul style="list-style-type: none"> • Quadrilha • Forró 	<ul style="list-style-type: none"> • Keep the Quadrilha dancing, but more organized and with typical dress • Adapt the spaces- squares to make cultural manifests
Local Cuisine	<ul style="list-style-type: none"> • Typical Brazilian candies • Cuscuz 	<ul style="list-style-type: none"> • Keep the wood burning stove
Economic or Handmade production	<ul style="list-style-type: none"> • Brazilian Beak Chili(Pimenta Biquinho) jelly made by Association of Bento Rodrigues (AHOBERA) • Individual crochet • Rug • Cattle raising, hen farms and pig farms • Production and selling of milk, cheese, eggs, flour, vegetables, fruits, Jabuticaba fruit wine and liqueur cachaça • Sewing • Fishing • Needlework • Honey and propolis extract • Vegetables and fruits • Stone made with fat 	<ul style="list-style-type: none"> • Keep the AHOBERA • Course of sewing • Increase the selling of the typical products • Create new places to keep the farming • Create places in the festivities to sell the homemade products • Set up handcraft association

OCCUPATION OF THE PLACE		
SUBJECT	BEFORE THE DISASTER	WHAT THEY WANT FOR THE CITY
COMMERCE (centralised or not)	<ul style="list-style-type: none"> Decentralisation, inside the house of the owners Variety of commercial area(butcher, market, bar, restaurants, small fairs, cloth store, tool store and domestic tools) No pharmacy 	<ul style="list-style-type: none"> Keep the decentralisation commerce inside the house or in the backyards Creation of others spaces for commercial area to have more establishments like pharmacy, supermarket, lottery store (lottery store in Brazil is a place where people can receive some benefits from the government, it works like a bank), etc
SERVICES/ PUBLIC EQUIPMENTS (CENTRALISED OR NOT)	<ul style="list-style-type: none"> School, Health clinic, Post Office: decentralised Elementary and middle school Small squares in the neighbourhood Court – outside of the school for multiple uses Communitarian Association of Bento Rodrigues- not so much participation 	<ul style="list-style-type: none"> Centralisation of the public services Construction of the court in the school Construction of Bento Rodrigues square close to the new church São Bento with benches, good illumination, landscape project, playground, etc. Creation of small police office Enlarge the school offering also High School and school for adults Buy an ambulance Increase the appointments in health clinic
RELIGIOUS BUILDINGS	<ul style="list-style-type: none"> Three catholic churches(São Bento, Nossa Senhora das Mercês and Igreja Velha), and two evangelical (Baptist and Assembleia de Deus) located in opposite sides of the city (North and South) and decentralized. 	<ul style="list-style-type: none"> Special areas for religious temples divided in the neighbourhoods, not to close of the housing because of the noisy and not so close each other Construction of Large Cross Construction of public restrooms
CEMETERY (REMOVE THE OLD ONE, BUILD A NEW ONE AND KEEP THE OLD ONE)	<ul style="list-style-type: none"> Located in the highest spot in the city, close to the chapel Nossa Senhora das Mercês 	<ul style="list-style-type: none"> Construction of a new cemetery- keep the proximity with the new church Nossa Senhora das Mercês. Construction of Wake Chapel
ENTERTAINMENT EQUIPMENTS	<ul style="list-style-type: none"> Ouro Fino Waterfalls Água Santa lake Soccer field Beira Rio Raimundo Luiz Court (close to the school), place used for festivities such as wedding's parties, birthday's parties and also for gym classes for the school Squares (São Bento and in the neighbourhoods)- decentralised Bars Vegetable famings and raising of small animals Batizal- area close to the city used to do picnics Igreja Velha Ouro Fino Farm 	<ul style="list-style-type: none"> Construction of squares with benches, illumination, fountain, open air gym, park for kids, parking, jogging path, gazebo. Plant adult plants and do a landscape project The main square should be in the central area and close to the church São Bento Construction of the Soccer field with restrooms and elevated bleachers. It should have an easy access Construction of the court/ Gymnasium or multiple space Construction of natural wells(place where people can take a bath)
RELATIONSHIP WITH NATURE	<ul style="list-style-type: none"> Strong relationship with the earth(plant of vegetables, fruits and medicinal plants) and the raising of small animals(chickens, duck, pig) The Waterfall Ouro Fino and Água Santa were used by the community To get the water from waterfall Ouro Fino and the Samarco's Mining Company Pump House. The system was not good Extraction of gold Rivers/ streams: Ouro Fino, Gualaxo, Mirandinha, Santarém and Água Santa 	<ul style="list-style-type: none"> Guarantee current potable water everyday Keep places in the houses to plant vegetables and fruits, and the raising small animals(pigs, chickens)
VISION OF THE DEVELOPMENT OF THE CITY	<ul style="list-style-type: none"> People are looking for terrains in Bento Rodrigues for living Not so much terrains available for the expansion Potencial for the economic touristic development(Project for the Park of Mining), AHOBERA(Association of Horticultural Grocery items of Bento Rodrigues), art craft production(candies, sweeties, rugs) 	<ul style="list-style-type: none"> The expansion should be around the city Give courses and make stronger the associations Pavement in all the access to the city Installation of cell phone tower

MOBILITY		
SUBJECT	BEFORE THE DISASTER	WHAT THEY WANT FOR THE CITY
Inside the village	<ul style="list-style-type: none"> • On foot • Bikes • Moto • Car 	<ul style="list-style-type: none"> • Bike path • Prioritize the pedestrians and the bikes • Keep the same name of the streets and the old configuration of the streets • Properly size for sidewalks(since colonial city it was usual not have sidewalks) • Properly size for streets, and illumination • Policing and security in the school
Outside the village	<ul style="list-style-type: none"> • By bus, by car, moto, lift, on foot, on horse • The schedule bus line is poor, it works only weekdays • No transport for health treatment, it is necessary take private car. It is expensive 	<ul style="list-style-type: none"> • More offer of time for buses also in weekends • Bus stops • New buses lines • Better access to the city
Types of roads in the village	<ul style="list-style-type: none"> • Almost the streets with cobblestones • The main street made with asphalt • Off road to access the soccer field • Some streets are offroad • Narrow streets without sidewalks, illumination 	<ul style="list-style-type: none"> • Pavement in the main street and the others with cobblestones • Two way road not divided by central strip • Large street with a better illumination • Try to keep the same old configuration • Construction of bike paths • Reactivation of Project “Estrada Parque Caminhos da Mineração” to visit the mining park
Accessibility to the schools	<ul style="list-style-type: none"> • On foot • The high school is only in another city Santa Rita, and the access is poor • No proper transport • Mud, dust, and sometimes the students arrived late or on foot 	<ul style="list-style-type: none"> • Build a high school in Bento Rodrigues or make a better access to Mariana, Antonio Pereira, Santa Rita e Camargos • Better car signals
Accessibility to close villages	<ul style="list-style-type: none"> • No maintenance , poor off roads, since it rains a lot many times the access is complicated • Access to the Bento Rodrigues is off-road • Transport of students made by bus or van • Bad bridge • A lot horses in the roads 	<ul style="list-style-type: none"> • Pavement road between Bento and Mariana • Make a better traffic signals in the roads • Make a better conditions in the roads to Mariana, Antônio Pereira, Santa Rita, Camargos • More frequency of buses to Bento Rodrigues
Uses of the community	<ul style="list-style-type: none"> • Live • Study • Plant • Entertainment(soccer, churches) • Fish • Work 	<ul style="list-style-type: none"> • To have fun, live, work • Better existing access • Build bike paths
Accessibility to disable people	<ul style="list-style-type: none"> • Poor access for disable people • The transport public is not adapted for disable people • There is no ambulance in the city to do transport for other cities • The churches do not have stairways • No existing sidewalks • Puddle of water in front of the school which it blocks the ramp in the entrance 	<ul style="list-style-type: none"> • To observe the accessibility for disable people in the streets, sidewalks and all public places and buildings.

HOUSING		
SUBJECT	BEFORE THE DISASTER	WHAT THEY WANT FOR THE CITY
Architecture style (antique colonial,modern colonial and modern)	<ul style="list-style-type: none"> • Some façades were colourful and others white. • Room's height more than 3 meters • Floor: ceramic, red cement • Windows: almost made of wood/ colonial style • Mud Roof tile • Almost the housing are colonial • Houses with front porch • Division of spaces inside the house: the kitchen and living room are bigger than other ones. • The window frame and door frame are in one colour and the rest of the house is in another colour • All houses had internet, light and spring water • Windows are made with wood, glass and metalon • Grid, sliding doors made with iron and metalon or iron and metalon • Houses have walls, wire fence, green fence, bamboo fence, open porch with grid • Backyard, open-air porch, garage • Living room, pantry, rooms, almost the house has 3 bedrooms • Few houses made by adobe, almost made with brickwork, some with 2 or 3 floors 	<ul style="list-style-type: none"> • The ceiling clearance(headroom) is high • House in colonial modern style • Windows and doors by wood(colonial style) • The door frame and window frame could be coloured in different or in the same colour of the house • Roof tile in colonial style • Lateral garage • Open air porch distant from the street alignment with garden • Backyard in earthen floor • Façades in strong colour and inside the colour are lighter • Ceramic floor, not in white colour • Wall or wire fence to guarantee the security, but it is necessary good ventilation, high close to the neighbours and lower in the frontal side • Infrastructure: internet, light, water, big water tank • Glass panels for bathroom boxes • Place for pets
Cultural aspects in the housing(wood-burning stove, place with social interaction)	<ul style="list-style-type: none"> • A lot plants and flowers; • Everybody has a house with backyard • Some of houses used to have a covered terrace in the last floor with barbeque, tables, laundry place • Wood burning stove inside the house or outside • The terrains used to have the fence to delimit the area • Slate in front of the houses • The houses used to have orchard, fruit trees and vegetable garden • Good earth to plant all types of plants • Chicken coop, pets • Big kitchens, garden 	<ul style="list-style-type: none"> • Besides the kitchen inside they want another kitchen outside with wood- burning stove in continuation of the house • Keep the backyard in earthen with space for orchard, vegetable garden, chicken coop, house for the dog, house to keep the firewood • Delimitation of the terrain: wall mixed with brick and fence since it is possible to have privacy, security and ventilation • All most the houses with 3 or 5 bedrooms • Place for workshop, like sewing workshop, etc. • Windows and doors made by wood • Terrace in the last floor
Relationship with the neighbours	<ul style="list-style-type: none"> • Few violence, • Nice relationship with the neighbours, feel like a family • Big families • The kids are happy • Freedom to walk in the city 	<ul style="list-style-type: none"> • Keep the relationship with neighbours, at least in the same street • Construcion of small police station • Construction of cell phone tower • Keep the configuration of the houses with porch, big kitchen

