

塑料浪潮：  
开采漂浮塑料垃圾的景观过程

**A PLASTIC TIDE:  
MINING FLOATING PLASTIC WASTE  
THROUGH LANDSCAPE PROCESSES**

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https://doi.org/10.15302/J-LAF-20180412  
 收稿时间 RECEIVED DATE / 2018-07-31  
 中图分类号 / TU986.2, X5  
 文献标识码 / A

## 塑料浪潮：全球紧迫性

据联合国估计，全球每年生产的3亿吨塑料中有40%在一年内被废弃。尽管大部分不可降解塑料垃圾都会被运到垃圾填埋场进行处理，每年还是有大约700万吨塑料垃圾进入海洋，并逐年被慢慢分解成越来越小的碎片<sup>[1]</sup>。不同于农业和工业废物等其他常见污染物，寿命很长、无处不在且数量惊人的塑料垃圾已成为一项真正的全球性挑战。如果没有替代品，我们只能在未来数年里继续依赖塑料制品。

目前主流的塑料废物处理遵循3R原则，即减量化（reduce）、再利用（reuse）和再循环（recycle）。由于塑料制品的减量化与再利用需依靠个体层面的努力，所以很难建立行之有效的制度。再循环则不同，在政府的支持下，通过将一系列复杂过程制度化与工业化，则可以实现再循环。我们应该如何应对塑料浪潮并提高资源利用效率？

## 塑料浪潮下的中国与东南亚

世界海洋中的塑料垃圾有60%来自中国、印度尼西亚、菲律宾、泰国和越南这五大快速增长的经济体。这些国家的国内生产总值近年来显著增长，工业水平及人民生活质量大幅提高，对一次性消费品的需求也随之增长。然而，其废弃物管理能力与经济增长速度并不匹配。为了逃避缴纳垃圾税或垃圾运输费，一些非法建筑工地和某些垃圾处

理公司甚至直接把垃圾抛进大海。

把塑料垃圾抛入海洋的行为会造成一种垃圾已被处理的假象，而实际上潮汐却常把漂浮的塑料垃圾推回岸边。在《海洋碎片：对布特莱斯湾海洋可持续性的直接威胁（2012）》一文中，史蒂芬·D·A·史密斯指出，广阔的海洋浅滩以及像红树林、沿海定居点这样的滨海消浪结构，都是海洋漂浮塑料垃圾易聚集的区域。<sup>[2]</sup>

## 原生高脚屋聚落

原生临海村庄受到了海浪作用下回岸塑料垃圾的严重影响。为了减小海浪的冲击，传统的临海村庄通常立于高脚架之上。村民以捕鱼为生——但是现在渔网捞到的却多是塑料垃圾。这些村庄受海洋文化影响显著，建筑与环境处处体现着海洋文化。村民们从邻近的森林砍伐木材建造房屋，从城市购买波浪状金属材料制作屋顶。渔民们依潮汐涨落开展捕鱼活动，他们的住所多采用贝壳装饰，别具地域特色。然而近年来，海浪源源不断地裹挟着塑料碎片涌上海滩，漂浮塑料垃圾正在淹没这些独特的村庄。

## 塑料垃圾回收产业

在本研究关注的地区——马来西亚的哥打京那巴鲁，已建立起5座垃圾处理中心和2个回收点，专门清理塑料浪潮。遗憾的是，这些基于村民们回收塑料的初心所建立起来的项目，却面临着发展受限和运营时断

### 摘要

据联合国估计，全球每年生产的3亿吨塑料中有40%在一年内被废弃。按照这样的速度，到2050年，海洋中的塑料可能比鱼类还要多。全球海洋中的塑料垃圾有60%来自中国、印度尼西亚、菲律宾、泰国、越南等发展中国家。大部分塑料垃圾在漂流到太平洋之前，就已在南海内停留了两年之久。随着中国的垃圾回收工厂转移到东南亚地区并开始从世界各地进口废弃物——相较于从本国海域中回收的脏塑料，进口的塑料垃圾既便宜又干净——这导致当地的塑料垃圾问题愈发严峻。此外，2017年再生塑料价格跌至前所未有的低点，进一步打击了当地人回收塑料的积极性。这项毕业设计通过设计一种促进漂浮塑料垃圾回收的结构，加强沿海拾荒者的谋生能力。本项目将塑料浪潮视作一种可以被开采、粉碎、清洁、干燥、烘烤和冷却的“资源”，并提出能够高效、完整地实现这一过程的景观系统。

### 关键词

回收利用；塑料制品；大洋垃圾带；废物管理

### ABSTRACT

The United Nations estimates that 40% of the 300 million tons of plastic produced each year are disposed of within a year. At that rate there could be more plastic than fish in the sea by 2050. Developing countries such as China, Indonesia, the Philippines, Thailand, and Vietnam contribute up to 60% of the plastics waste drifting in the world's sea. Much of the plastic is trapped in the South China Sea for two years before drifting out to the Pacific Ocean. The plastic problem has increased as Chinese recyclers have relocated to Southeast Asia and began importing waste from all over the world. The imported plastics are cheap and clean, outcompeting the dirty plastics collected locally from the tides. The recycled plastic price dropped to unprecedented level in 2017, discouraging plastic scavenging by locals. This thesis empowers the waste pickers by designing structures that incentivize plastic recycling. The thesis proposes that the plastic tides can be mined, shredded, cleaned, dried, baked, and cooled in an efficient and holistic landscape system.

### KEY WORDS

Recycling; Crafting Plastics; Plastic Garbage Patch; Waste Management

译 刘姝 陆小璇

TRANSLATED BY LIU Shu LU Xiaoxuan

1. 再生塑料

1. Recycled plastic



时续等问题，究其原因是一些项目缺乏推动村民参与的经济动力。

全球的回收塑料价格持续波动。中国政府自2017年以来施行了“禁废令”，禁止进口外国废弃物，这意味着中国的全球废品回收量占比从70%下降到了15%。这一变化使全球回收塑料的价格再创新低。路透社2018年1月报道称，中国垃圾回收公司目前正在马来西亚选址建造回收工厂，将塑料垃圾转移到法规宽松且腐败猖獗的东南亚地区。

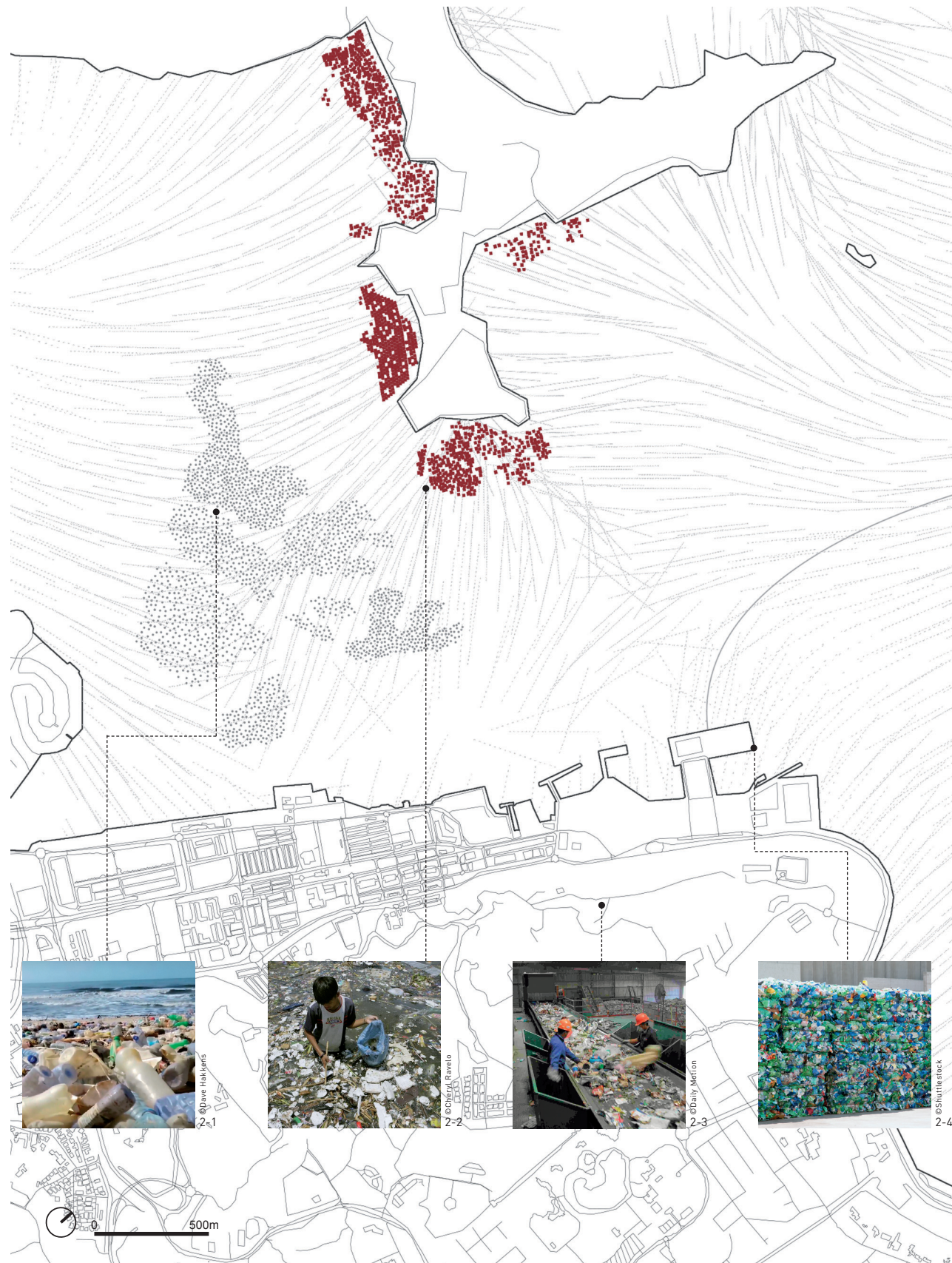
这些新成立的回收工厂正在利用跌至最低点的回收塑料价格从中谋利。发达国家廉价的塑料垃圾不再出口到中国，而是定期海运到东南亚地区。东南亚回收工厂通过从中国购买二手设备，将廉价的塑料垃圾转化为再生塑料颗粒以获取经济利益。这些搬迁到东南亚的中国回收工厂可能会受到严厉的谴责，因为只有“这些中国企业从东南亚新建的回收工厂中获利最多，而昂贵的环境清理费用最终将由当地居民承担”。<sup>[3]</sup>

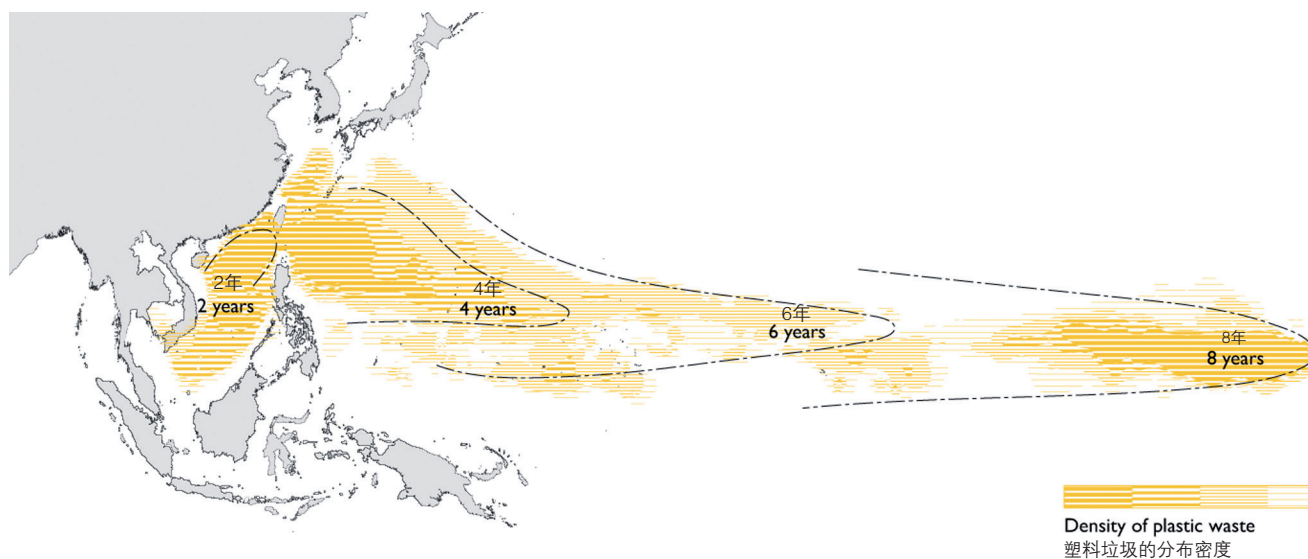
## 回收过程的去中心化

有关垃圾回收的讨论与行动，总是聚焦于那些动辄耗资数百万美元的大型机械。这些资本密集型大型回收工厂虽然运作高效，但投资并拥有这类项目的是少数中国企业家，他们通常偏好处理进口废料而非回收本地的脏塑料，导致本地垃圾回收价格低廉，进而使得从事本地垃圾回收的人少之又少。因此，对大型回收工厂的关注对清理塑料浪潮没有帮助，反而可能导致塑料垃圾累积现象进一步恶化。

第二，由于大型回收工厂以机械化操作为主，因而它们创造的就业机会很少。随着东南亚城镇人口的不断增长，在当地亟需更多新的就业形式的情况下，这些低就业率的大型回收项目非常不受欢迎。与之相比，劳动密集型的垃圾回收工作，反而能够提供更多就业岗位。

最后，从市场需求看，大型回收工厂生产的再生材料质量远远超过绝大多数市场需



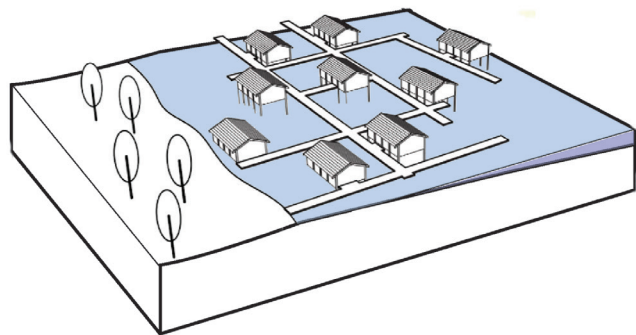


2. 场地地图
  - 2-1. 塑料浪潮
  - 2-2. 塑料垃圾回收村
  - 2-3. 塑料垃圾回收工厂
  - 2-4. 货运塑料垃圾进口
  3. 世界海洋中的塑料垃圾有60%来自中国、印度尼西亚、菲律宾、泰国和越南这五大快速增长的经济体。
  4. 原生高脚屋聚落
2. Key map
  - 2-1. Plastic tide
  - 2-2. Plastic village
  - 2-3. Plastic industry
  - 2-4. Plastic shipments
  3. 60% of the plastics waste drifting in the ocean can be traced to originate from just five rapidly growing economies, China, Indonesia, the Philippines, Thailand and Vietnam.
  4. The indigenous stilted settlement

求。例如，只有一小部分客户需要产品的强度、加工和外观达到再生塑料板材的标准。换言之，再生塑料制品是一种奢侈品，对大多数东南亚人来说并没有吸引力。大型回收工厂需要大量资金、培训和巨大的消费市场。没有这些，回收工厂只能依赖外部市场提供原材料和出口销路。

### 设计命题：塑料景观

本设计提出了一种基于简单技术的塑料回收系统。它把临海村庄的村民纳入到塑料经济循环中，既减少了回岸塑料垃圾的数量，又给村庄带来了实实在在的经济效益。设计方案改进了现有的回收技术并实现了生



产多样化，使之能够生产出满足多种需求的产品。一系列的回收工作坊与活动被引入滨海景观之中，在模拟完成大型工业化回收过程的同时，亦可利用景观过程生产新的再生塑料：

1) 捕集单元：捕集器由一系列插入海底的高6m、等高距为2m的木桩支撑，以60度角面向海洋收集垃圾，同时留出船只通道。这个由100根木桩组成的捕集系统每月能够收集20kg塑料或1 000个塑料瓶。

2) 分拣单元：长宽为15m×40m的垃圾分拣中心紧邻捕集单元，以尽量减少垃圾处理的操作步骤，并防止在收集过程中发生意外伤害。PET、PVC等类型的塑料在回收过程中会产生有害烟雾；如果将各种塑料混合处理，可能导致其他元素掺杂，使得产品质量不合格。分拣中心为塑料加工提供了更安全的工业空间。

3) 清洁单元：如果在冲洗垃圾时混入盐水，则会导致清洁失效。因此冲洗将在池塘进行，以避免对海水造成水体富营养化等生态危害。

4) 粉碎单元：粉碎垃圾需要消耗大量电能，因此需要根据不同的塑料类型选择混合、磨碎或切碎处理。若不计电费，粉碎单元的造价为500~3 000美元。

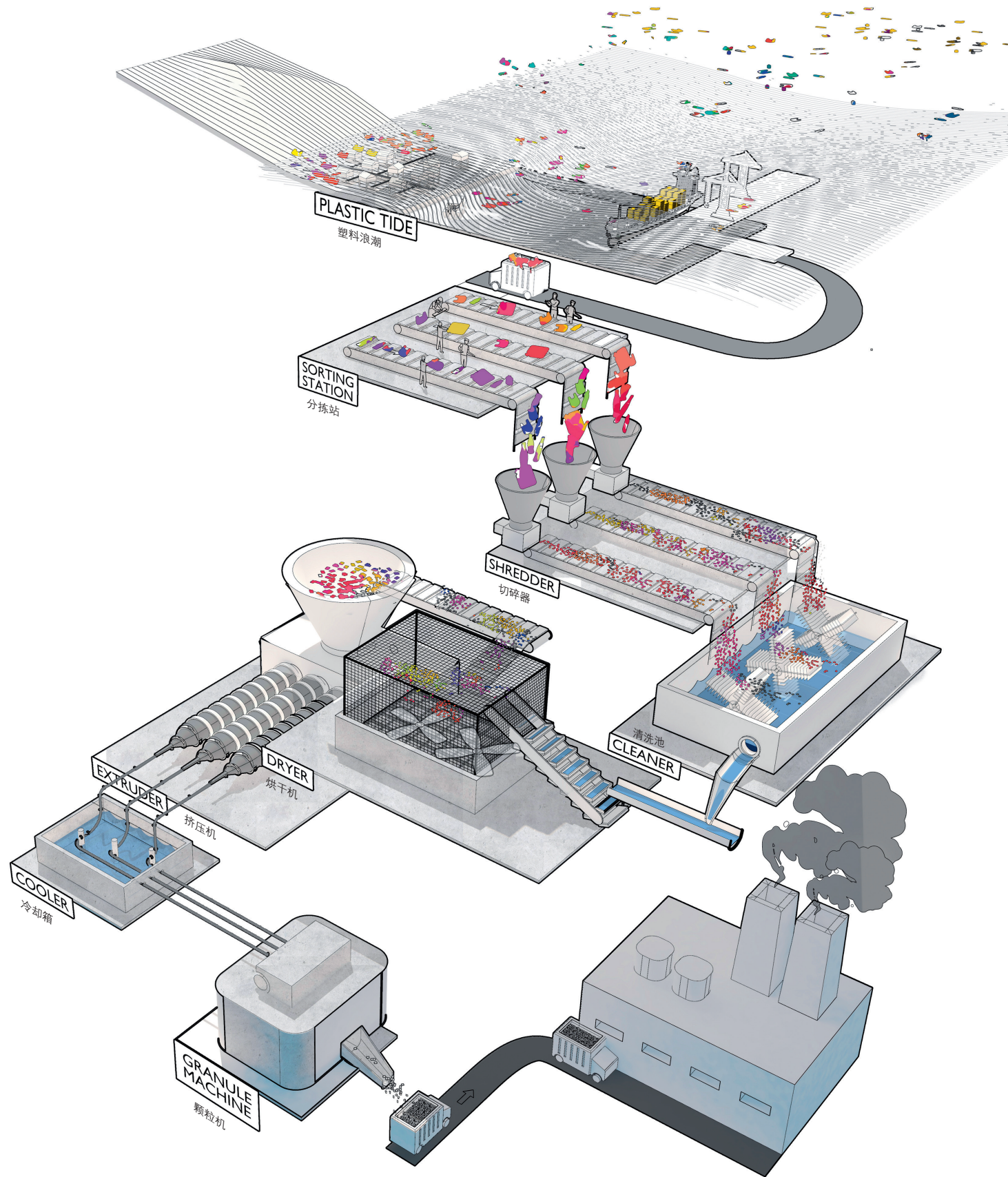
5) 干燥单元：露天自然晒干耗时半天，虽然比机器烘干慢，但更加节能。

6) 窑烧单元：熔融塑料会散发轻微有毒的挥发性有机化合物（VOCs）。通过引入窑烧单元，可以制造低氧环境，最大限度地减少VOCs的产生。窑炉可结合景观建于地下，顶部覆土并建成绿色屋顶，有利于控制和吸收VOCs。

7) 冷却单元：完成塑料加工必要冷却步骤的水流最后汇入清洗池，成为可供村民使用的淡水。

### 强化乡土聚落以抑制城市化

上述目标得以实现的关键在于精心规划与多方协调，从而实现景观改造过程中的最少施工及对生态的最小破坏。东南亚当前的经济增长是以本土知识遗失和空间恶化为代价的。临海村庄的高脚屋聚落维系并再现了宝贵的马来海洋文化。景观设计师可以通过设计方案支持当地经济发展、促进当地劳动力就业，进而使得临海村庄的自然及人文景观得以保存。在该项目中，塑料景观为滨海社区注入了垃圾资源循环这一亟需的产业形式，继而帮助抑制城市化对滨海原生聚落的侵蚀。LAF



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## Plastic Tide: Global Urgency

The United Nations estimates that 40% of the 300 million tons of plastics produced each year are disposed of within a year. While much of these non-degradable wastes are dumped in landfills, around seven million tons of plastics waste end up in the sea each year where it then breaks down into smaller and smaller fragments over the years<sup>[1]</sup>. Unlike any other common types of pollution such as agricultural and industrial runoffs, the longevity, ubiquity, and sheer volume of discharged plastic debris is now emerging as a truly global challenge. Without an alternative to plastic we will continue to depend on it for many years to come.

The popular maxim for managing plastic waste revolves around the 3Rs of reduce, reuse, and recycle. However, since reduction and reuse require compliance on an individual level, it has been difficult to establish institutional support for each. Recycling, on the other hand, requires a series of sophisticated processes that can be institutionalized and industrialized with government support. How can we increase the resource efficiency by tackling the issue of plastic tide?

## China and South-East Asia in the Plastic Tide

Five rapidly growing economies, China, Indonesia, the Philippines, Thailand, and Vietnam, are responsible for 60% of plastic waste in the oceans. As these countries have enjoyed significant increases in GDP, industry and quality of life, demand for disposable consumer products has also grown and waste management has not been commensurate with growth. Illegal construction sites, and even some waste contractors, have been found to directly dump refuse into the ocean to eschew waste tax or transport fees.

Dumping plastic into the ocean gives

a false impression of disposal and often results in tides sweeping the floating plastic waste back to the shores. In “Marine Debris: A Proximate Threat to Marine Sustainability in Bootless Bay (2012),” Stephen D. A. Smith identifies wide expanses of ocean shallows and wave attenuating structures, such as mangroves and coastal settlements, as areas that attract plastic.<sup>[2]</sup>

## The Indigenous Stilted Settlement

Indigenous waterfront villages are one type of location heavily affected by plastic washing onto beaches. Often built on stilts that attenuate waves, these villages depend on fishing from ocean traps. Increasingly, these traps are filled with plastics. These villages are defined by their maritime culture, and the built environment of the villages reflects this culture. Timber is harvested from the adjacent forest, and corrugated metal is collected from the cities for roof materials. Fishing is timed with the waves and homes are decorated with seashells to construct a unique image of place. These unique villages are being inundated by floating plastics with incessant waves debris cluttering the shores.

## Plastic Waste Recycling Industry

In the study site of Kota Kinabalu, five garbage centers and two recycling points have been set up to clean up the plastic tide. The effort relies on the villager’s initiative to recycle and has been limited and inconsistent because it has not offered any financial motivation for the villagers.

The global price of recycle plastics continues to fluctuate. Since 2017, the Chinese government has banned the import of waste products, meaning that China now recycles only 15 percent of the global supply, as compared to 70 percent previously. Without the consistency of the Chinese market, global prices have dropped

to a new low. Reuters reported in January 2018 that Chinese companies are now locating recycling plants in Malaysia, moving plastic dumping to Southeast Asia where regulations are lax and corruption is rife.

These newly established recycling plants are taking advantage of record low plastic prices. Rather than exporting waste to China, cheap plastic waste now arrives in regular shipments from developed countries who sell their waste to others. Economically, Southeast Asia now is benefiting by buying second-handed equipment from China and turning dirt-cheap plastic waste into recycled plastic granules. These relocated Chinese recycling processors may receive severe reprimands as only “Chinese-owned firms will profit the most from the establishment of new workshops in Southeast Asia, leaving local populations to eventually pay for costly clean-up operations.”<sup>[3]</sup>

## Decentralizing the Recycling Processes

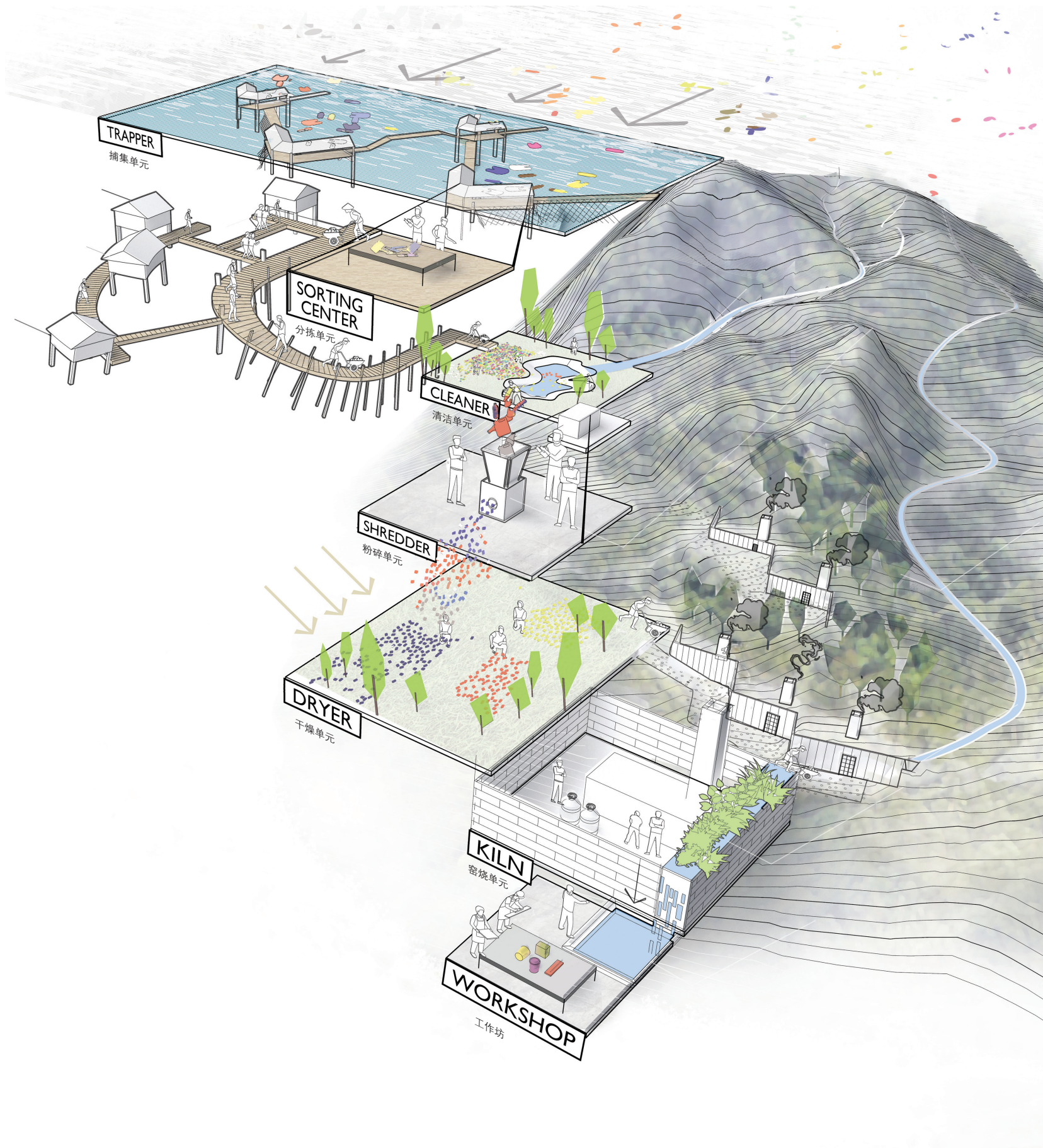
Significant focus has been placed on large-scale machinery that can cost millions of dollars to purchase. Investing in these kinds of recycling factories is capital-intensive, and although efficient, they are owned by a small number of Chinese owners who prefer processing imported scraps over domestically recovered dirty plastics. As a result, people dissuaded from collecting recycling because of the low prices. The focus on large-scale recycling will not help clean up the tides and may worsen plastic accumulation.

Second, large-scale recycling creates minimal opportunities for employment since it is mechanized. In Southeast Asia, where urban populations are growing and new forms of employment are needed, this is particularly unwelcome. Although waste collection is labor intensive, it provides a needed form of employment.

Finally, the recycled materials produced at the large-scale plants are too high-quality

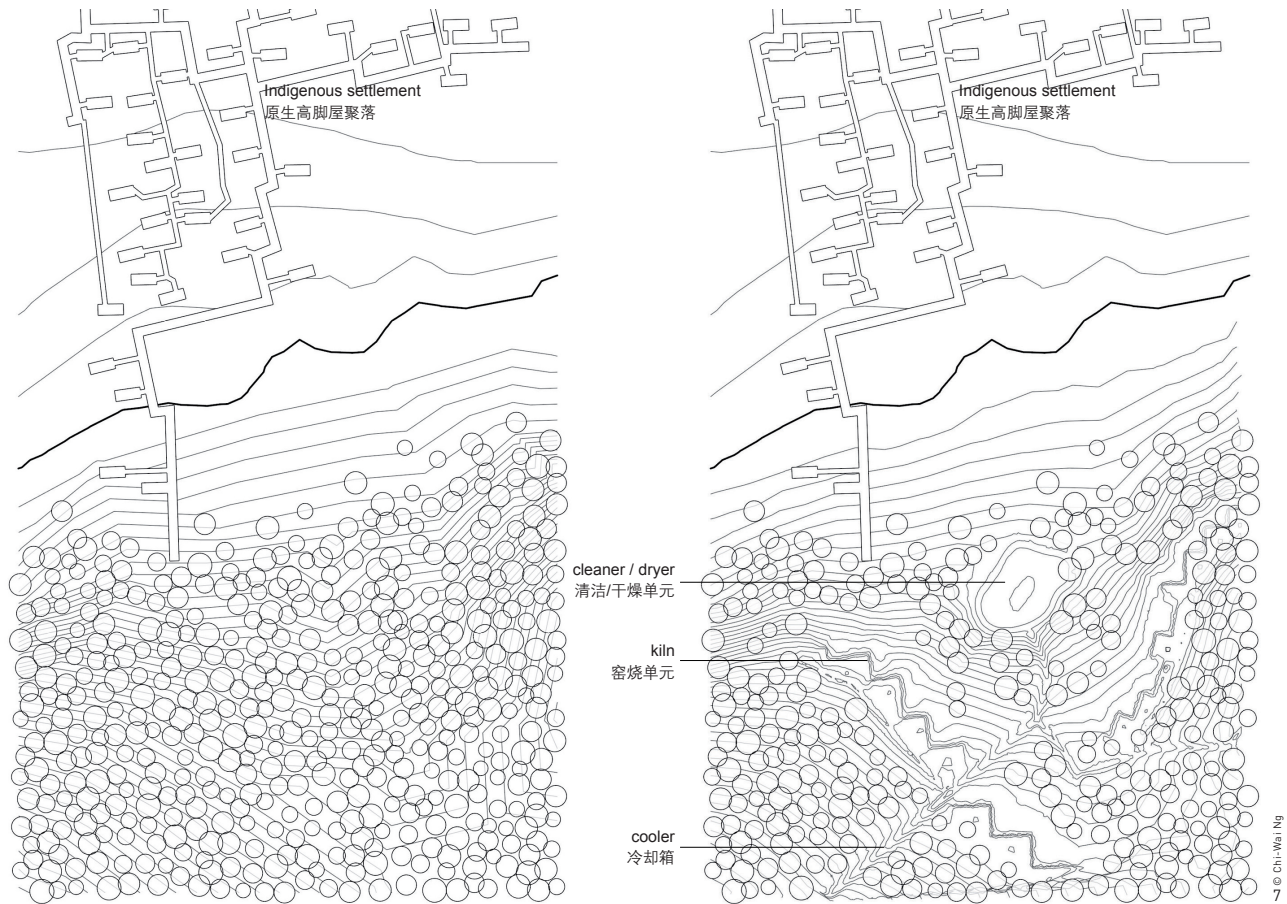
5. 塑料垃圾的回收流程

5. All proposed processes



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- 6. 项目强调改造过程对环境的最小干预。
- 7. 项目改造前后景观的变化
- 6. The proposed site operations put emphasis on minimal earthworks.
- 7. Change of landscape



for most markets. The strength, finish, and look of recycled plastic lumber, for example, is unlikely to be needed for more than a small fraction of users. In other words, the plastic produced is a luxury without mass appeal for most in Southeast Asia. Investing in recycling demands a high level of capital, training, and large market for consumption. Without this support, factories depend on outside markets for the raw materials and exports.

### Design Thesis: The Plastic Landscape

The design proposes a system of plastic recycling built on simple technologies. It incorporates waterfront villagers into the economic cycle of plastic, reducing the volume of waste and bringing financial

benefit to the villages. The design diversifies and refines existing recycling technology to create products that appeal at a variety of scales. A series of workshops and interventions will be installed in the landscape to replicate the industrial recycling processes while also harnessing the landscape to craft new recycled plastics:

1) Trapper: The trapper system operates at a 60-degree angle and provides boat and marine access through a series of six-meter timber posts piled into the seabed at a two-meter contour. A trapper system of 100 posts will collect 20 kilograms, or 1,000 water bottles, of plastic per month.

2) Sorting center: The 15-meter by 40-meter sorting center will be placed

directly next to the trappers to minimize handling of waste and prevent accidental injuries during collection. Some types of plastics, such as PET or PVC, produce harmful fumes during the recycling process. Mixing plastics may produce subpar products with undesirable material properties. The sorting center provides a safer industrial space for the processing crafting of the plastics.

3) Cleaner: Cleaning plastics requires rinsing washing that does not work when mixed with salt water. Instead, washing activities will take place at ponds to avoid ecological hazards such as eutrophication.

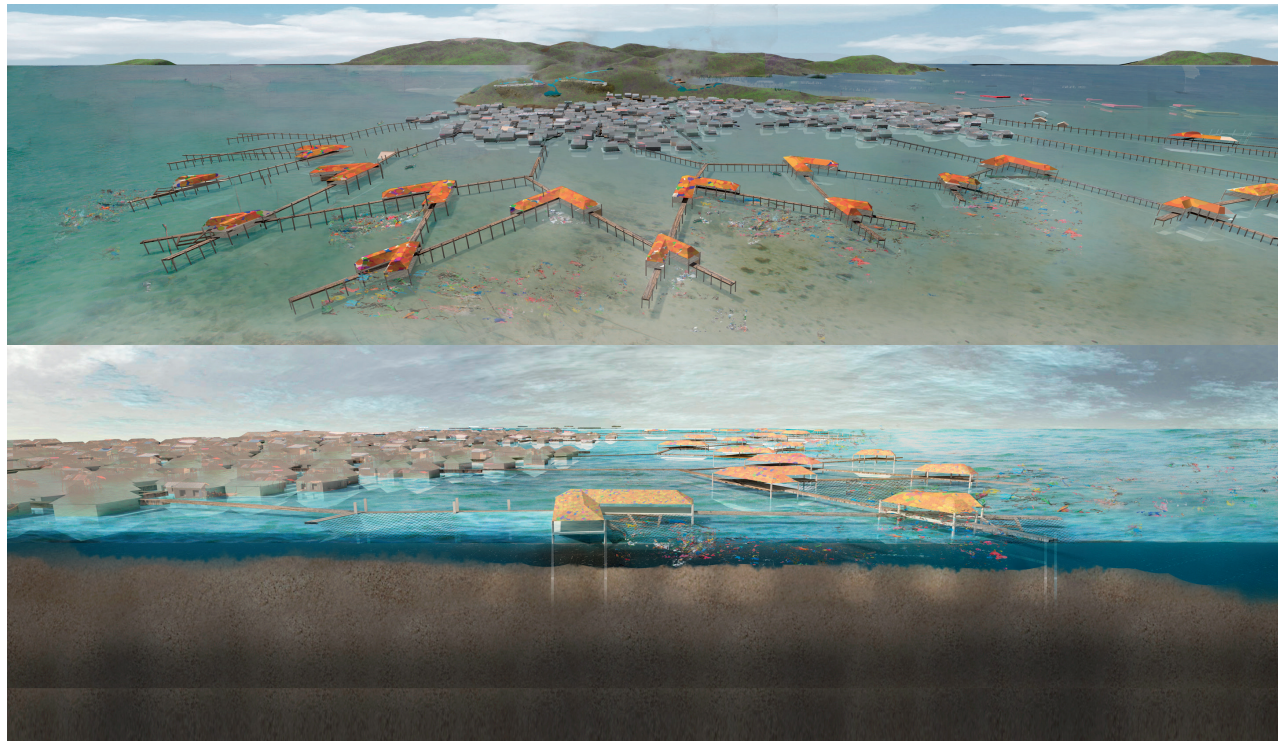
4) Shredder: Shredding requires massive electricity use. Depending on the model the plastic can be blended, ground, or shredded. The processing units cost between USD 500



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8. 塑料制品样本
  9. 融汇了当代回收工业及原生高脚屋聚落的混合景观
  10. 捕集单元和塑料浪潮的关系
  11. 塑料景观
- 
8. Samples of crafted plastics
  9. Landscape as incubator for modern industry with indigenous settlement to coexist
  10. Relationship between trapper and the floating plastic pieces
  11. Plastic landscape

to USD 3,000 plus the cost of electricity.

5) Dryer: Open air drying from the sun can take half a day, and although slower than machine drying, is more energy efficient.

6) Kiln: Melting plastic emits mildly toxic VOCs (Volatile Organic Compounds). By embedding kilns in the landscape creates a low oxygen environment that minimizes the VOCs. The subterranean kilns are contoured to the landscape and covered by earthworks and green roofs which help contain and absorb the VOCs.

7) Cooler: Finally, the stream that feeds into the cleaning pond, essential for finishing the crafted plastics, also provides access to freshwater for the villagers.

### Equipping Indigenous Villages to Stand Against Urbanization

To accomplish all the above goals, a well-planned and well-coordinated landscape transformation with minimum ecological and earthwork disturbance is critical. Southeast Asia is facing economic growth at the cost of indigenous knowledge and spatial deterioration. Stilted housing settlements maintain and offer an invaluable sense of the Malay maritime culture. Landscape architects can help ensure that these settlements continue to exist by bolstering local economic activities and by empowering the local labor forces through design schemes. In this example, the plastic landscape introduces a needed recycling industry that can help stand against rapid urbanization. **LAF**

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