



Eco-Restoration and Wealth Creation

—Elion's Kubuqi Business Model



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Foreword

The lethal impact of climate change and environmental mismanagement are increasing the force and frequency of sand and dust storms. Desertification affects the health, wellbeing and livelihoods of billions of people around the world, especially women, children, and the poor. It disrupts food, education, transport and communication. And it creates an unbearable financial burden for countries and their citizens. However, this report shows how one public private partnership is reversing this cycle, creating wealth and putting communities on the road to sustainable development.

Spanning over 18,000 square kilometers, the Kubuqi Desert is the seventh largest desert in China and was once a significant source of dust storms in Northern China and Beijing. But, for the last 30 years, the Elion Group, led by Chairman, Wang Wenbiao, has been restoring degraded land to support economic growth in the area.

For example, Elion's liquorice plantations in the area is known as a 'sweet deal' for the company, the growers and the environment. Elion gets a quality cash crop. People like Wu Zhihua and her family benefit from a technical expertise and guaranteed sales. And the environment benefits from the natural nitrogen fixation and soil improvement properties of the plants. With growing techniques that improve efficiency tenfold, one unit of liquorice is worth about 450 RMB (US\$75) to local farmers, while the sandy area becomes fertile farmland in just two or three years.

This is just one of many initiatives fighting back against the sand and dust storms. From tourism to solar energy, the benefits of a whole range of activities have already restored more than a third of the Kubuqi Desert and lifted over 100,000 farmers out of poverty.

I have been fortunate to see the Elion Group's Kubuqi model first hand. I believe it proves how effectively innovative public-private partnership can boost both profits and sustainable development. Now I hope that it will inspire many more such initiatives in other areas fighting back against the desert.



Erik Solheim

Executive Director of the UN Environment
Under-Secretary-General of the United Nations

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Key Messages

Ecosystems are the most important asset of the global economic system. However, they are under threat and the extensive degradation of ecosystems has become one of the key constraints to achieving the global sustainable development agenda. Land degradation impacts the stability of the global economy and causes serious environmental problems. For many countries, the restoration of degraded ecosystems is an urgent priority. Ecological restoration is usually carried out through government-driven public financing platforms, with limited engagement from the private sector.

Elion Resources Group initiated its ecological restoration business in 1988, transforming from a salt chemical engineering business to an ecological restoration company. In the Kubuqi Desert, located in the Inner Mongolia Autonomous Region in China, Elion carried out large-scale ecological restoration activities, and successfully reclaimed 6,253 km² of desert land (out of a total project area of 11,000 km²). The key methods included the construction of sand-protecting barriers, afforestation, aerial shrub seeding and the closure of land for natural regeneration. Since then, Elion has expanded its ecological restoration activities into other regions, including Hebei Province, Gansu Province and Xinjiang Uygur Autonomous Region, reclaiming a further 850 km² of degraded land.

After nearly 30 years of practice, Elion has developed a comprehensive ecological restoration-based economic system, and developed an effective collaborative model by which the private sector, the public sector, the local population and the international community (also known as PPP+ model) can work together in mutually-beneficial partnership. In addition, Elion also takes advantage of Kubuqi's abundance of sunshine and land to produce solar energy for supplying electricity to local communities, schools and industrial sectors. Solar energy has not only become an important business for Elion, but also helps local communities to access clean energy and supports local factories in reducing their carbon footprint.

Elion's success is built on the following components:

- 1. An effective business model based on collaboration:** An effective business model based on collaboration is critical to a company's long-term success and its ability to raise capital and grow successfully. Elion started as a salt chemical engineering company in the heart of the Kubuqi Desert. Severe sandstorms occurred frequently and caused serious damage, affecting the production of salt and its derived chemical products together with high transportation costs. There was an urgent need to combat desertification and sandstorms. Elion started planting a greenbelt made of trees around its factory and along the main road. This greatly reduced the formation and movement of dunes. Elion realized that only a collaborative effort between stakeholders would achieve its restoration goals. Therefore, Elion developed a collaborative partnership composed of the private sector (Elion), the public sector (national and local government), the people (local communities) and other relevant stakeholders (technical institutions, international organizations) to restore the degraded Kubuqi landscape.
- 2. A smart business structure based on long-term vision:** The ecological restoration industry requires long-term vision, commitment and investment, before it can become profitable and sustainable. The expectation of short-term returns is one of the main causes of failure of many ecological restoration projects. A strategic business structure comprising of short-term needs and long-term business goals is essential for sustaining business development. Elion used its short-term return on investments in the salt chemical industry to sustain its business operation and provide the initial capital for its ecological restoration activities. This long-term focus and approach allowed Elion to invest in the new restoration industry, which eventually provided returns on the initial investment. At the same time, tackling the ecological crisis required technical innovation. Licorice, a local drought-resistant

medicinal plant, was introduced as an effective means of stabilizing the sand, while also enabling Elion to build its medicinal product business.

- 3. Socioeconomic return:** Restored degraded desert ecosystems generate multiple returns: inspirational capital, social capital, natural capital and financial capital. Through the PPP+ collaborative model, Elion created ecological wealth, with a higher economic value than the direct financial return. This has successfully reduced poverty within the surrounding communities by creating employment for both men and women, as well as providing technical support for increasing the productivity of their land – adding value to land resources and improving ecosystem services.

'I never thought planting trees would make me rich'.

Local resident

In partnership with UN Environment and the United Nations Convention to Combat Desertification (UNCCD, 2016), Elion mobilizes thousands of local community members for annual tree and grass planting activities. Socioeconomic return has become an important driver of regional development. Most importantly, all the key stakeholders benefited from the ecological restoration projects, strengthening collaboration between them. Socioeconomic return facilitates and strengthens Elion's business development, increasing its social and political impact, and brand awareness.

- 4. An adaptable and replicable model:** The ultimate goal of Elion's Kubuqi collaborative model is to scale up the restoration of degraded lands by creating business opportunities through partnerships elsewhere. From its humble beginnings in the Kubuqi Desert, Elion's ecological restoration initiatives have been successfully

replicated in other regions in China. Elion is also planning to grow its business overseas. However, ecological restoration needs to be adapted to local specificities, due to the differing dynamics of the natural environment and socioeconomic context. Therefore, Elion's Kubuqi business model needs to be flexible enough to adapt, replicate and scale up to meet the demands of ecological restoration initiatives in different parts of the world.







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1. Rationale, Purpose and Scope

Ecosystems are the primary assets of economic systems, providing materials and services to all economic activities. According to UN Environment, ecosystem services are worth between US\$21-72 trillion annually (the world gross national income is US\$58 trillion) (Ferwerd, 2015). The key ecosystem services include the provision of soil fertility, food, fodder, water, shelter, carbon sequestration, goods, medicines, stability, pleasure, knowledge and leisure (MA, 2005; Chen et al., 2006). At the global level, around 2 billion hectares of land are degraded and 60 per cent of ecosystem services are under threat (UNCCD, 2014; MA, 2005). Deserts are among the most severely degraded ecosystems and desertification is one of the most serious environmental issues, affecting more than one-fifth of the world's population from two-thirds of the world's countries. (D'Odorico, 2013; Proceedings of the fifth Kubuqi International Desert Forum, 2015). Annual global economic losses from desertification and droughts are as high as US\$42 billion (UNCCD, 2012). Since desertification has severe consequences for ecology, the environment and society, it is important to ensure and maintain ecosystem health (Shi et al., 2005; UNCCD, 2014). Efforts to prevent desertification and land degradation protect the natural resources that support livelihoods, and ultimately provide the natural capital that underpins sustainable development.

China has more than 2.6 million km² of desert, accounting for 27.2 per cent of its total territory (State Forestry Administration, 2015). A great deal of effort has been made to control desertification in China. Between 2009 and 2014, China reduced its desert area by 2,424 km² annually (State Forestry Administration, 2015). However, desertification remains one of the most severe forms of land degradation and has a huge socioeconomic impact on the population, leaving both men and women vulnerable to food shortages and natural disasters. Women, however, tend to be more directly affected as they usually have the important role of

fending for their families and managing their family land; while in most cases, men look for opportunities for income outside their communities.

The desert restoration efforts by Elion Resources Group provide a unique model of successful practices for desertification control. It attributes its success to its initial will and ambition to survive and the nature of its private operation. Elion started with the construction of windbreaks primarily to protect its factory and roads, which are located in the middle of the Kubuqi Desert – the seventh largest desert in China. Since 1988, Elion has reclaimed over 6,000 km² of land – from a total project area of 11,000 km². Elion's ecological restoration business has expanded to other desert areas in the Inner Mongolia Autonomous Region, Hebei Province, Xinjiang Uygur Autonomous Region and Gansu Province. Over nearly 30 years of practice, Elion has built up a unique collaborative model that involves the public and private sectors, local people and the international community –otherwise known as the PPP+ Kubuqi Model. The successful implementation of the project has generated a large amount of ecological wealth: a win-win mechanism of ecological conservation, livelihoods improvement, and economic development on a regional scale.

Particular attention was paid to gender issues when designing the ecological restoration approach, including job provision for women near their communities (while the men seek job opportunities elsewhere) and inclusive capacity-building for both men and women. In fact, a number of women have even organized their own labour groups to work with Elion's projects (UNCCD, 2016). In addition, Elion has invested in boarding school facilities for children, which has helped in reducing the workload for women caring for the families.

In 2014, Elion's ecological restoration project was selected as a UN Environment Green Economy Pilot Initiative. A comprehensive scientific review was conducted in 2013-2015 (UNEP, 2015). Building on the review, this case study examines the operational mechanism and collaborative

model for Elion's ecological restoration projects. It includes an analysis of the structure and estimation of the value of ecological wealth created from Elion's large-scale ecological restoration work. It demonstrates the integrated profit-making mechanisms through a comprehensive desert green economy approach. By disseminating this information, the report aims to expand the application of this innovative approach in restoring large-scale degraded ecosystems for the benefit of local communities.

It is commonly recognized that the direct financial return from ecological restoration projects is usually low, or in deficit. Therefore, it is difficult to establish an effective incentive to attract investment in ecological restoration businesses. For this reason, most of these types of projects are financed through public funding. This report describes the 'returns' on investment from ecological restoration projects through a comprehensive assessment of the total wealth created and the services provided through such projects. It will help inform decision makers of the processes and benefits of ecological restoration in large-scale degraded ecosystems.



2. Overview of the Kubuqi Business Model

Elion Resources Group was established in the Inner Mongolia Autonomous Region of China in 1988. The initial core business was a salt production factory, located in the centre of the Kubuqi Desert, the seventh largest desert in China. The business gradually transitioned from a chemical industry to an ecological restoration industry. Elion engaged intensively in the ecological restoration of the Kubuqi Desert and developed a unique business model for ecological restoration. The evolution of Elion's Kubuqi business model – which is built on the integration of environmental protection into a broader private business operation – is described in this section.

2.1 Geography and Climate

Kubuqi Desert is located in the Hanggín Banner of the Inner Mongolia Autonomous Region, China. It is on the northern edge of the Ordos Plateau, south of the Great Bend of the Yellow River. The Ordos Plateau is a unique geographical feature and its sandy and denuded landscape is in sharp contrast with adjacent areas. The altitude ranges from 850 m to 2,130 m above sea level, with approximately 3,100 annual sunshine hours.

The Kubuqi Desert extends 400 km from west to east and 50 km from north to south, with an area of 18,600 km² and an altitude of between 1,200 m and 1,400 m above sea level. Moving dunes (mainly trellis dunes and chain dunes) account for 61 per cent of its area. The surface is covered by loose sand and more than 81 per cent of the surface sand particles are graded as fine sand (0.1–0.25 mm).

According to data from the Hanggín Banner Meteorological Station (the nearest meteorological station), the Kubuqi Desert is characterized by a temperate continental arid monsoon climate with a long cold winter and warm short

summer, and a windy spring and cool autumn. January is the coldest month, with an average temperature of -11.7°C and an extreme minimum temperature of -32.1°C. July is the hottest month, with an average temperature of 22.1°C and an extreme maximum temperature of 38.7°C. The annual average temperature is 6.4°C. The average annual precipitation is 280 mm, unevenly distributed across seasons; rainfall in June, July and August accounts for 65 per cent of the annual total rainfall. The annual water pan evaporation is 2,630 mm, of which nearly 74 per cent occurs between May and October. The wind speed increases from northwest to southeast, with frequent gales (24.6 days per year on average) in the spring. Sandstorms occur on an average of 13.2 days per year.

2.2 Evolution of Business and Development of Ecological Restoration

Elion Resources Group started its business in ecological restoration soon after the company was established in 1988. The company started as a salt chemical factory on the salt flats of Hanggin Banner. There was no infrastructure connecting the factory to the power grid or water supply and no road access; the factory was under constant threat from sand deposition. To protect the salt flats and factory facilities from sand damage, the company started planting trees in the area surrounding the factory. A small 'fund' was set up for this purpose: 5 yuan was collected from the profits of every ton of salt and a forest team consisting of 27 workers was organized. This small project brought about positive results.

A bigger constraint on the development of the business was the high transportation costs. The salt flats were only 65 km as the crow flies from the railway station, but the actual transportation distance was 350 km, at an average vehicle speed of 10 km/hour. The unpaved roads were under constant threat from sand deposition and were continuously changing due to the drifting sand and

shifting dunes. A proposal was put forward to build a 65 km-highway connecting the factory to the Wula Mountain railway station. Elion invested 70 million yuan in the road construction. However, the new road was also under severe threat from the moving sand. Following the success of the tree planting around the factory, a proposal was developed to plant a greenbelt of trees along the road. Although it was common knowledge that sand dunes could be stabilized by trees, little guidance was available on which trees to plant and how to grow them. The Elion team invested a great deal of effort into choosing appropriate plant species and planting technologies to establish a greenbelt along the road. It was not easy to find suitable plant species that could adapt to the cold, drought and alkalinity of the soil. A number of species were trialled and eventually a few plants such as liquorice (*Glycyrrhiza glabra L.*), willow (*Salix mongolica*, *Salix psammophila*) and littlelife peashrub (*Caragana microphylla*) (Wang et al. 2012) were found to be suitable for the adverse desert conditions. After three years of tree planting, the project created a 65 km-long, 4 km-wide green corridor, which protected the new tarmac road from the sand. At the same time, water supply and telecommunication infrastructure were also built along the road -- the first trans-Kubuqi highway. The highway enabled the salt industry to prosper, leading to the establishment of the Elion Resources Group, and the transition from a salt chemical business to an ecological restoration business.

The key techniques developed for the ecological restoration business included the construction of sand-protecting barriers, reforestation, land closure for natural regeneration, aerial seeding, and the cultivation of licorice and other desert crops. To date, Elion has successfully reclaimed 6,253 km² of desert land in the Kubuqi Desert (from a project area of 11,000 km²). Elion's ecological restoration business expanded into other desert areas, including Shanghai Miao (Mu Us Desert) and Keerqing Shadi in Inner Mongolia; Bashang (Zhangjiakou City) in Hebei Province; the Takelamake Desert in Xinjiang Uygur Autonomous Region; and Minqin, Gulang and Liangzhou (the Tengger Desert) in Gansu Province – reclaiming another 850 km². The total area of restored desert land has reached more than 7,100 km².

There were three distinct phases in the transformation of Elion's business model (Figure 1), evolving from a salt chemical engineering company to the present-day ecological rehabilitation enterprise, which combines ecology, livelihoods and economic development. In the first phase (1988-1995), Elion, as a salt chemical engineering enterprise, explored possible measures to improve the desert environment. In the second phase (1995-2005), Elion expanded its ecological business into cultivation and the processing of Chinese medicinal plants, and an exploration of solar energy and other green economy elements.

By the end of this phase, Elion had completed its transformation. Since 2005, Elion has been expanding its desert restoration business and now focuses primarily on ecological restoration. It successfully developed its core business structure: the full integration of ecological restoration, comprising of green land, green energy and green financing, linked by the Internet; and formulated its unique ecological profit-making business model.

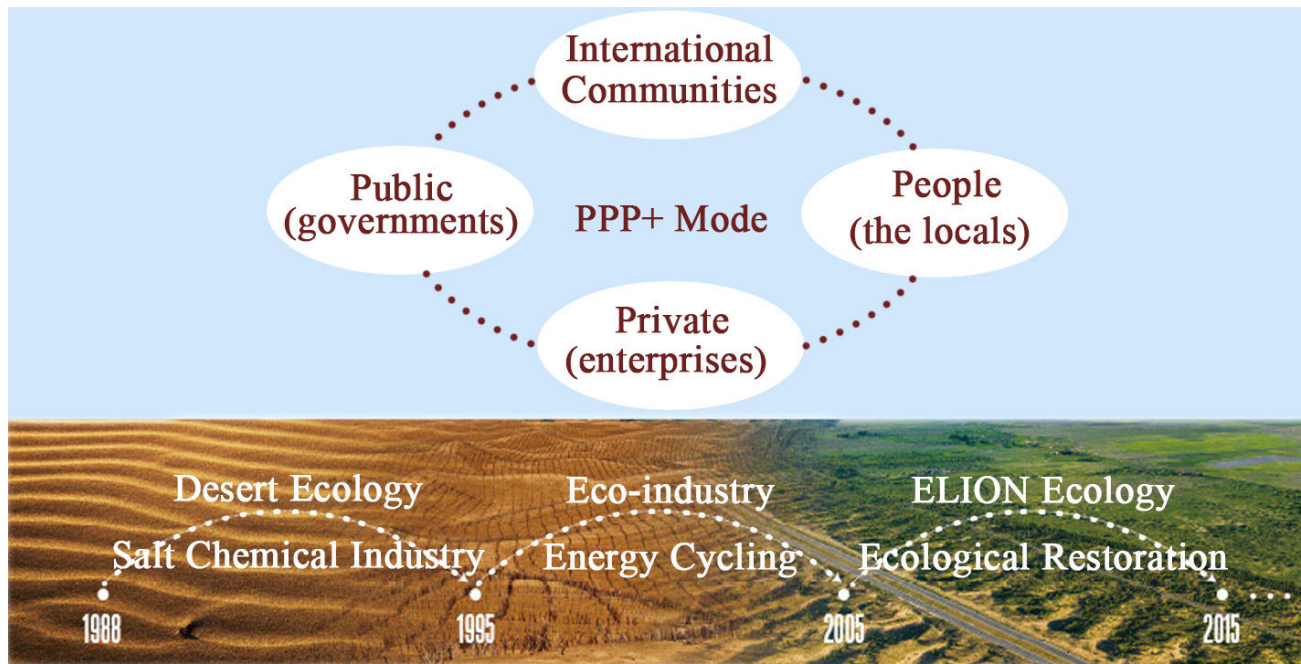


Figure 1 Evolution of Elion's Kubuqi business development

Elion Resources Group has made a positive contribution to sustainable development by integrating ecological protection, livelihoods improvement and regional economic development into a balanced 'win-win' operation. The Kubuqi model is based on a desert green economy. With the investments from Elion, large-scale engineering and biological measures were installed to improve the natural regeneration of the ecosystems. This generated a tremendous amount of ecological wealth consisting of inspirational return, social capital, natural capital and financial return (Figure 2).

Inputs: Inputs from Elion included funding, labour, technology and materials. Funding is fundamental to generating ecological wealth from the desert. In total, Elion has invested 3.15 billion yuan in its ecological operations alone. Most of the funding came from Elion itself, while a small portion came from public investments from the government. So far, a total of 30 billion yuan of venture capital has been invested into the whole ecological industry of Elion (comprised of ecological restoration, ecological animal husbandry, ecological tourism, ecological health, ecological energy and ecological engineering). Human

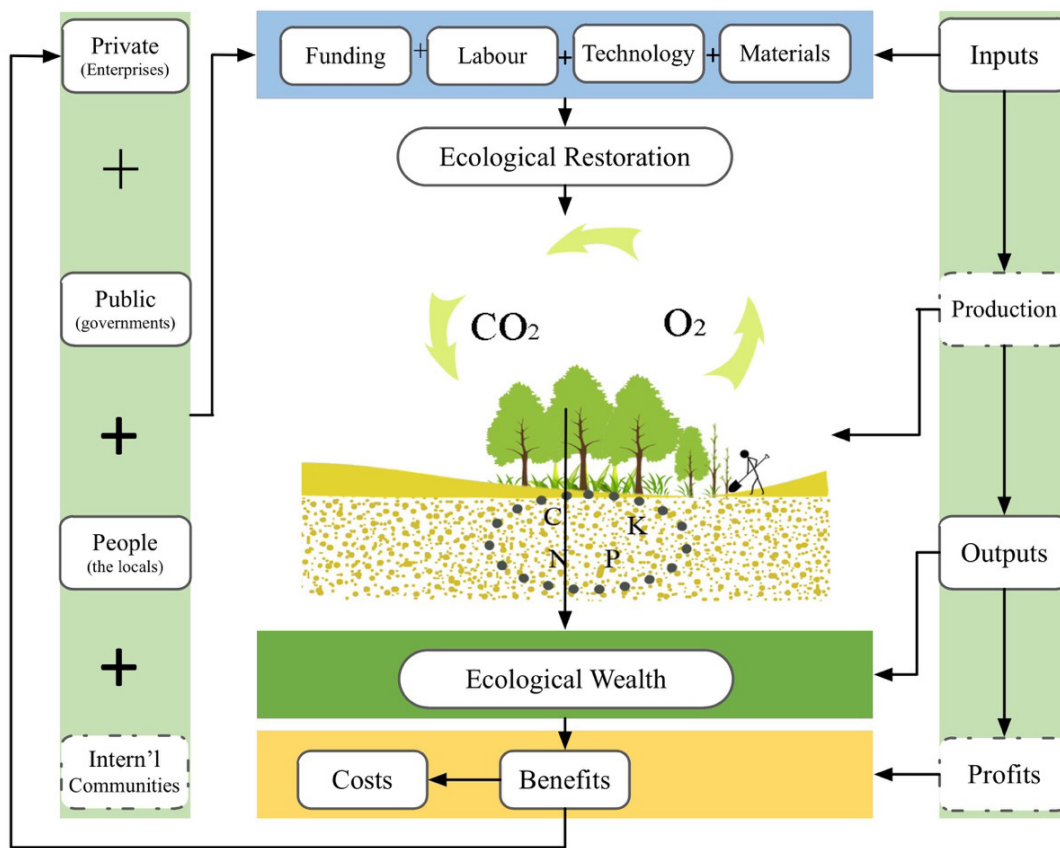


Figure 2 Kubuqi business model and creation of ecological wealth

resources included both technical personnel and labour provided by local communities. Women played a crucial role, providing labour for most of the ecological restoration activities, such as raising seedlings, transplanting and the daily maintenance of plantations. Technical personnel were responsible for project management, technical support and R&D for new products; while labour was used for implementing activities in the field: ranging from installing sand-protecting barriers, tree/shrub/grass planting and the harvesting of licorice roots. The key technological inputs included the selection of plant species, tree planting techniques, sand dune fixing techniques, intercropping, methods for growing licorice, transplanting and daily maintenance. Since ecological restoration needs a large amount of technological input, research and training were also important.

Outputs: As the desertified areas are gradually restored, the ecosystems' functions recover and the value of ecological assets slowly increases. The direct outputs from restored ecosystems are increased crop cultivation, animal husbandry and fish production. In 2014, the Kubuqi ecological restoration area produced 159 tons of vegetables and fruits, and fish production reached 25 tons. Cultivated licorice roots have a very high medicinal value: they are an important material for healthy food production and yield high profit margins. There are 85,000 ha of licorice plantations producing as much as 3,000 tons of fresh licorice roots annually. An extensive agricultural, animal husbandry and medicine production system has been successfully established.

Furthermore, the improved ecosystems provide a better environment, where high quality houses, schools and production bases are supported by ecological services, increasing the value of the land. In the Kubuqi ecological restoration area, Elion has built new villages for local herdsmen, the Elion Oriental School, production bases for the Elion Natural Medicine Group, a sand industry, solar energy facilities and the Qixing Lake Scenic Spot (Kubuqi Dessert Park) – all of which support the green economy. At the same time, large-scale reforestation has increased

the vegetation coverage, which contributes to water and soil conservation, effectively changing the microclimate. Carbon sequestration is another important function of the improved ecosystems. In the Kubuqi project area, the total amount of sequestered carbon reached up to 14.5 million tons. Accumulated forest litter increases the soil fertility due to the higher organic matter content. The desert vegetation provides important habitat for wildlife and contributes to biodiversity conservation (Research on the Contribution of Eco-Restoration of Kubuqi Desert to China's Climate Change Initiatives, 2015). The improved ecological environment has also encouraged the development of tourism. The desert and Kubuqi Oasis is now attracting more tourists. Elion, in cooperation with local communities, initiated a desert eco-tourism industry, providing transportation, accommodation, food and special programmes for the tourists – further expanding the income-generation options. In 2014, Qixing Lake Desert Park received 51,451 tourists.

Elion created assets from its innovations. Many technological inputs for desertification control have been developed, ranging from cultivation techniques to improvements in the utilization of plant products. The development of new techniques and other innovation activities has reduced implementation costs, and produced knowledge assets. To date, Elion Resources Group has obtained five patents for utility models and two patents for invention; five more patents are pending an evaluation process. The patents could generate a total potential profit of 2 billion yuan. So far, Elion has collected 1,000 plant materials that are suitable for desert restoration.

In addition, Elion has provided job opportunities for local communities. During the planting seasons, Elion provides employment for between 8,000 and 9,000 people, and another 1,000 jobs are created during the licorice harvesting season. Through the direct provision of jobs and the flow of other benefits to locals, Elion's poverty alleviation efforts have raised the living standards of more than 100,000 people in surrounding communities. The case study below illustrates the positive impact on local livelihoods:

Wu Manping, a local woman who works for Elion Green Land Technology Company, undertakes project feasibility surveys and legal risk prevention and control analyses. Wu said that Elion has helped ensure her family's quality of life:

"I feel I'm contributing to creating a green world. I feel valued and I'm happy. We, the women of the 80s generation, have the important responsibility of caring for the elderly and raising children, and at the same time we can realize our dreams. Thanks to the Kubuqi Desert control project, we do not need to do what many women in other remote areas do —leave their homes to make money and sustain their families. Instead, we can work here and look after them. My female colleagues have all benefited in this way."

Some of the project benefits cannot be calculated in monetary terms. For example, the benefits from new knowledge/techniques that have been transferred to locals who have participated in the project and their improved understanding of ecological protection. The overall improvement to the local economy is also beneficial to social stability and the happiness of villagers. The implementation of Elion's social responsibility plan has provided better education opportunities to local communities. The road construction has improved accessibility in the region. The improved ecological environment is also good for mental and physical health. These types of benefits are difficult to monetize, but are nonetheless important for regional sustainable development.

Profit-making

The restored desert ecosystems and the restoration business has been very profitable for Elion Resources Group. In 2014, the total output value of Elion reached 28.7 billion yuan, and the net profit reached 1.2 billion yuan. The profits were able to cover the initial investment costs and were used to further expand investment in desert control and other business enterprises, allowing Elion to widen its business scope. In addition, a portion of the plant materials produced were sold directly for profit, and a portion were used as input into the processing business, creating value-added profit and increasing the ecological assets. The Kubuqi Desert Green Economy is a successful model for enterprises to follow, combining business development with environmental protection – a win-win scenario. A comprehensive assessment of the wealth created from the ecological restoration projects indicate that financial assets generated at least three times their value in ecological wealth for the benefit of the public.

2.3 PPP+ Model and the Key Stakeholders

Throughout its nearly 30 years of desert control operations, Elion Resources Group has built close collaborative partnerships among 'public, private, local community and international organizations' – a unique collaborative model for ecological restoration, known as the Kubuqi PPP+ model (Figure 3).

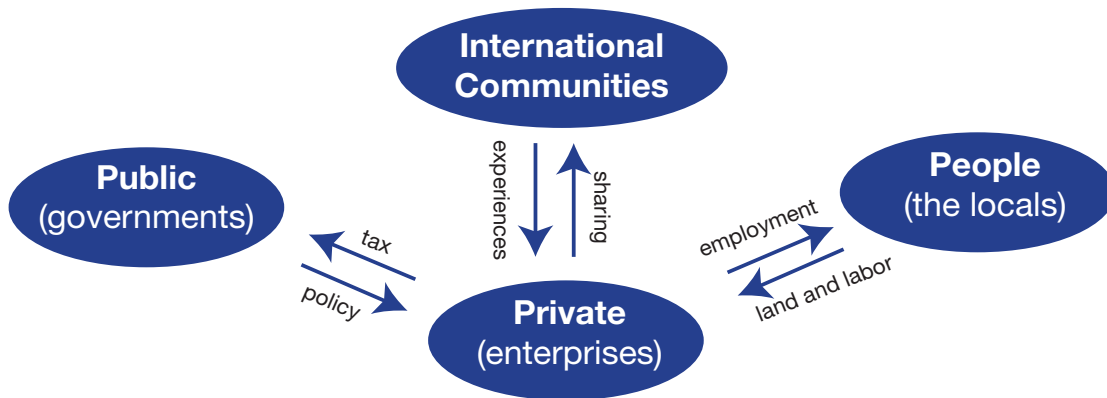


Figure 3: Elion's PPP+ model for ecological restoration

Private enterprises play the key role in implementation of the desert control business. Through collaboration with the government, private enterprises get funding and policy support, as well as recognition and encouragement. Well-developed private enterprises repay the public through taxation, which supports regional development. The active participation of local communities ensures the supply of labour. Locals earn an income and benefit from technical training from the project, creating a mutually-beneficial relationship between private enterprises and local communities. International organizations can help private enterprises in establishing networks for publicity, sharing experiences, strengthening research and gaining wider recognition. At the same time, enterprises can provide models of good ecological restoration practice that can be scaled up.

In fact, PPP+ has evolved from the well-known PPP model for public investment. Public-Private Partnerships (PPP) form the basis of Elion's collaborative relationship with the government. PPP was the initial model of operation in Elion's ecological restoration project. With policy support from the government, Elion was able to maximize its capital and technical advantages to effectively restore the degraded ecosystems, while accumulating a significant

amount of ecological assets for the company. The PPP model is the fundamental mechanism for successful desert control. However, under the local land tenure system (see section 2.3.2 for more detail), it would have been difficult for Elion to operate if only the public and private sectors were involved in the partnership. Therefore, Elion collaborated with local communities and international organizations. The local people played an important role by contributing skills and labour, while international organizations helped Elion to develop a platform for effective publicity and technical consultations. This expanded the PPP model into a PPP+ model. Such strong collaboration ensured effective business operations, and supported a better ecological culture for development.

Besides the effective and innovative partnerships, Elion created its own 'ecology + profit-making' business model that relies totally on the sand as it is based on an interactive process of sand control and doing business based on sand. The effective business model is built on six key elements: ecological restoration, ecological animal husbandry, ecological tourism, ecological health, ecological energy and ecological engineering. This business model closely links ecology, economic development and livelihoods – the core of the Kubuqi business model.

2.3.1 Government Support

Favourable government policy is one of the key factors in safeguarding a company's business development. Ecological restoration is not only a commercial business operation, but it is also important for improving the human environment, beautifying the landscape and supporting regional economic development. The Kubuqi business model is highly regarded by the various levels of government and is supported with appropriate policies and encouragement.

Policy Support: The Chinese Government and local communities have paid close attention to Elion's ecological restoration activities. In the early 1990s, the Hangjin Banner Government adopted a land-use policy based on the principles of "who manages, who benefits, who plants, who owns" and 'established forests jointly owned by all collaborators'. These policies facilitated ecological restoration and increased the effectiveness of the project. The Kubuqi ecological restoration engineering operations also aligned with the priorities of the national 'Three-North' Shelterbelt Project in the 1990s, and Elion received 75 yuan/ha in subsidies from the government, which further encouraged Elion's efforts towards ecological restoration. In addition, the central and local governments provided financing policies to support ecological restoration businesses. A collaborative framework has been set up between Elion and financial institutions – such as the China Development Bank, the Commercial and Industrial Bank of China, and the Construction Bank of China – providing financial safeguards for the implementation of ecological restoration.

Furthermore, the governments opened up public investment projects to private companies, such as the public investment projects implemented by the Desertification Control Convention. Through market mechanisms, Elion took up these public projects as services providers or contractors.

Recognition and Encouragement Encouragement from the Government was important in stimulating innovation and gave Elion the confidence to develop its ecological restoration business. It was also an important driving factor for the successful implementation of the project. In May 1995, Mr. Wang Wenbiao, Elion's Chair, was awarded the title, *Model Worker*, by the Inner Mongolia Autonomous Region. In 2000, and again in 2012, he was given the title, *National Model Worker of Afforestation* and awarded the *National May 1 Labor Medal*. The work of Mr. Wang Wenbiao and his team was recognized internationally when he was given the *United Nations Environment and Development Award* at the UN Sustainable Development Summit in June 2012. He also received the *Global Desert Control Leader Award* at the eleventh Assembly of State Parties of the UN Convention for Prevention and Control of Desertification in September 2013. These honours gave great encouragement to Elion, and its efforts in ecological restoration are now widely recognized, both at home and abroad.

2.3.2 Participation by Local Communities

The local population has participated directly in desert control. The local communities worked closely with Elion in implementing the ecological restoration project, granting the right to use their lands (obtained during the rural land reform in 1970s) and providing labour. A win-win partnership was established between the locals and Elion. Elion provided technical guidance, materials (seeds and seedlings) and technical support to local households for plant production. The locals became shareholders in the business and helped to increase the scale of production. At the same time, Elion hired local labour for tree planting, grass planting, irrigation and other agricultural activities. The locals also work in the factories (such as the medicinal plant processing factory), eco-tourism and green energy. More than 100,000 locals, both men and women, have benefited from the ecological restoration project. Women, in particular, have probably benefited the most from the ecological restoration of the desert.

2.3.3 International Collaboration

The Kubuqi business model is an open system. Elion's ecological restoration project develops interactive activities with international organizations, international desert control projects and training centres. It has also established a global expert team to further facilitate desert control activities through conferences and support to international networks for desertification control (Figure 4).

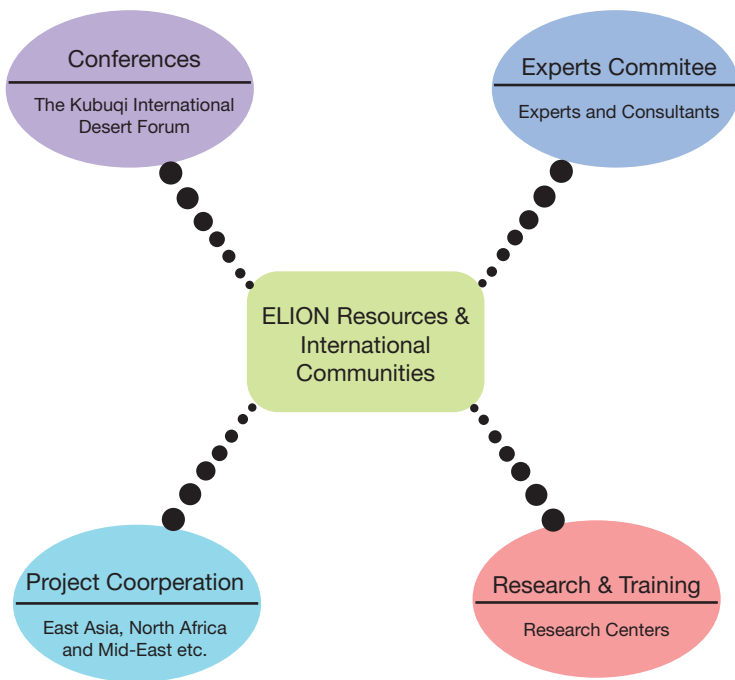


Figure 4 International cooperation in the Kubuqi model

Elion has developed and strengthened collaborative relationships with several international organizations such as United Nations Environment (UNE), International Union for Conservation of Nature (IUCN), United Nations Convention to Combat Desertification (UNCCD) and United Nations Educational, Scientific and Cultural Organization (UNESCO). Its international influence has strengthened Elion's image at home and abroad, making the Kubuqi business model a more globally recognized practice. In 2014, the Elion Foundation and UNE jointly organized the GEO-5 Green Youth Summer Camp.

The Kubuqi Desert Forum is a high-level platform for technological exchange and policy dialogue among key stakeholders (government and private sector). The Kubuqi Desert Forum has developed gradually, and is now organized biannually. It has become the supporting platform for implementing the work of the UN Convention of Prevention and Control of Desertification. In 2013, at the eleventh session of the Conference of the Parties (COP 11) to the UN Convention of Prevention and Control of Desertification held in Namibia, the Kubuqi Desert Forum was recognized as the "main measure and platform for global implementation of the Convention". In February 2014, the Chinese Government approved the Kubuqi Desert Forum as a large-scale international initiative. The forum is now jointly organized by UNE, the Secretariat of the UN Convention of Prevention and Control of Desertification, the Ministry of Science and Technology, the State Forest Administration and the Government of Inner Mongolia.

Elion is supported by a global team of experts comprising of ecologists from 57 countries. The expert team provided strong technical support to Elion's ecological restoration project. The expertise comes from the Israel Academy of Agricultural Sciences (ARO), the Ben-Gurion University of the Negev, the China Agricultural University, Beijing Forestry University, the Desert Research Institute of Chinese Academy of Sciences, Xinjiang Institute of Ecology and Geography, Inner Mongolia Agricultural University and the Chinese Academy of Forestry. Experts from the US, Australia and Europe also joined the team.

Elion provides training to strengthen its team and is planning to initiate a network of training centres, which aims to meet the need for professional ecological restoration human resources in developing countries. The members include the International Research and Training Centre for Combating Desertification in Turkey, the University of Central Asia and its campuses in other countries, the Federal University of Ceará (Brazil), the Argentinian Institute for Arid Zones (ADIZA), the Agrarian University of La Molina (Peru), the University of Chile (with its two centres), Pri Mehr Ali Glah University of Arid Agriculture (Ramalpuj), Karakum International University, Sheh Abdul Latif University (Kharpur), the Desert Research Centre of the Ministry of Agriculture of Egypt, the Arid Zones Institute of Tunisia, Brazil Bhuth University Shengil, the International Centre for Agricultural Research in Deserts and Drylands in Israel, and the Arid Land Research Centre of Ben-Gurion University of the Negev.

Elion understands the importance of information dissemination for scaling up the Kubuqi business model to contribute to the world's efforts in desertification control. It is planning to set up an effective Internet-based information sharing platform to share its experiences and lessons learned from the ecological restoration of large-scale degraded ecosystems around the world; as well as call for greater global collaboration in developing a healthier development philosophy that is supported by a well-established ecological culture.





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3. Ecological Restoration and Wealth Creation: Findings

The engagement of the private sector is still limited in the ecological restoration of large-scale degraded ecosystems. Elion's Kubuqi business model shows that it is important to create appropriate incentives to encourage the participation of the private sector. While in Elion's case, the initial motivation for ecological restoration was to meet its own needs – to survive in the heart of the desert – there are real benefits for other private enterprises. After nearly 30 years of practice, Elion has become a comprehensive enterprise, transforming its initial salt chemical business into an environmentally friendly business involving ecological restoration, clean energy, ecological health and green financing. Therefore, it is important to analyse the integrated benefits of the business model to better understand the potential for other private companies.

To understand the full spectrum of profits from ecological restoration, it is crucial to examine the total wealth created from such activities. Although the limited financial benefits are not particularly attractive to financial investors, the added benefits play an important role in building a solid foundation for future business development in the private sector, including improved ecosystem quality, socioeconomic development and favourable policy support. Thus, this section outlines a framework for a comprehensive impact assessment that describes the total wealth created from ecological restoration projects and assigns economic values to the wealth created to help inform decision makers. Although it is difficult to put a precise economic value on non-market based wealth, the framework aims to compare different components of the wealth created from the ecological restoration of large-scale degraded ecosystems and the benefits they provide. An approach combining both quantitative and qualitative methods is employed in this assessment.

3.1 Structure of Wealth Created from Ecological Restoration

In a comprehensive ecological restoration business, private and public sectors, local residents and international bodies work together to improve ecosystem quality and human well-being, ultimately creating wealth and providing benefits or returns to stakeholders. There are different types of returns, including:

1. **Inspirational Return:** Successful ecological restoration inspires people for future development, positively influences the ecological culture (at various levels) and creates leadership for long-term commitments to ecological conservation. In particular, it enables the accumulation of knowledge, technologies and operational skills, which are valuable resources for sustaining ecological restoration businesses.
2. **Socioeconomic Return:** Ecological restoration generates job opportunities, livelihood security and social cohesion for local communities. It also provides better education, health care and other social services to locals, and ultimately contributes to regional socioeconomic development.
3. **Green Land Return:** One of the obvious benefits from ecological restoration is the improved quality of land – i.e. from low-value waste land to higher-value ‘green land’ that can be used for further development projects. Therefore, ecological restoration adds value to land resources, which is a key element of regional development.
4. **Ecological Return:** Ecological restoration rebuilds ecosystem functions – which include biodiversity conservation, carbon sequestration, and soil and water conservation – adding value to ecosystems.
5. **Financial Return:** Successful ecological restoration operations provide financial returns to private enterprises through the provision of ecosystem products, income generated from processing industries and the expansion of business scopes through improved land resources.

3.2 Assessment of Wealth Creation

3.2.1 Inspirational Return

Elion’s success in reclaiming large-scale degraded deserts has helped to gain the confidence of all stakeholders and has provided renewed hope for the future. Examples of inspirational return are:

1. **Hope for future:** The oasis created by Elion provides a sustainable resource for local communities, giving them hope for the future. The oasis in the desert has also changed the development aspirations of key stakeholders, including governments, businessmen and locals, providing inspiration for future development.
2. **Leadership in ecological restoration:** Leadership skills were developed through implementation of the ecological restoration project, particularly in terms of technical development and business operations. The project trained many technical staff, who are now experts in ecological restoration techniques. As the pioneer of ecological restoration, Elion’s Chair, Mr. Wang Wenbiao, was recognized as a ‘model worker’ and a ‘global leader in ecological restoration’.
3. **Strengthening of the ecological culture:** The project demonstrated an important dimension of development: an ecological culture and a growing awareness of ecological conservation among local communities and government.
4. **Indigenous culture and happiness:** The project supported local communities to build new villages, helping them to maintain their indigenous culture and improve their living conditions, thus bringing happiness to the local population.
5. **The project also generated practical knowledge, technologies and skills for ecological restoration.**

3.2.2 Socioeconomic Return

During nearly 30 years of ecological restoration, Elion has generated a wealth of knowledge: concepts, technological developments, and models and institutions for transforming deserts into ‘green mountains, blue water, golden and silver hills’, which are recognized worldwide and have the potential for application in other areas. Ecological restoration serves to strengthen regional social development. Its key contribution in this regard is its integrated approach to safeguarding the livelihoods of the local population. The successful results of ecological restoration research and development drive regional economic development. Additional ecological restoration benefits include improved social services such as education, health care and access to markets.

Prior to ecological restoration, there were about 100,000 people living in poverty. Ecological restoration benefits the local communities in two ways: direct income generation from new job opportunities and increased productivity from their own lands as a result of the introduction of new technologies and improved ecological conditions. One social survey by local government and Elion in 2016 concluded that the per capital annual income increased from 747 yuan to 17,000 yuan in the project period – an average annual increment of 11.5 per cent. Of the 11.5 per cent, Elion contributed 3.83 per cent (one third of the annual increment) adding a total of 8,400 million yuan to local incomes. This is a highly significant contribution to helping local families, especially women, escape poverty, sustain livelihoods and enhance family well-being.

Elion’s investment in research and development has generated great progress after nearly 30 years of practice. Elion’s technical achievements range from the development of health products, organic fertilizer, organic fodder, environmental protection products, solar energy, modern water-saving technology and eco-tourism. Elion has developed 243 patented technologies with a total estimated value of 1,161 million yuan (based on the recent

average trading price of patented technology on the Beijing market), and made savings of 2 billion yuan in reforestation costs by using specialized tree planting technology. The total value generated from research and development is estimated to be 3,161 million yuan.

Elion’s ecological restoration project has provided additional social services to the region. Elion built a school and constructed the Yellow River Bridge and five roads with a total length of 500 km. All the infrastructural investments in the project areas have improved access to education, medical care and markets for the local communities.

3.2.3 Value Added to ‘Green Land’

The ecological restoration has contributed to regional socioeconomic development by adding value to land resources. The restored oasis provides a better environment for human settlement and the value of the land has increased. In the last 28 years, Elion reclaimed a total of 6,253 km² of land and another 4,763 km² is currently under restoration. Elion has also expanded its business to other regions and reclaimed a further 850 km². Based on the price of local land, the total increase in the value of the reclaimed land is 345,721 million yuan.

3.2.4 Ecological Return

The ecological wealth includes both the provision of products and ecosystem services. Since the production of products is part of Elion’s business operation, it is accounted for in Elion’s financial outputs. This section focuses on ecosystem services – the benefits people obtain from ecosystems.

Carbon sequestration and oxygen production:

Carbon sequestration is one of the important environmental services obtained from reforestation/re-vegetation. From 1988 to 2016, Elion's ecological restoration projects sequestered a total of 15.4 million tons of carbon, worth a total of 4,204 million yuan. It is estimated that the accumulated production of oxygen is 18.3 million tons, at a value of 6,762 million yuan.

Biodiversity Conservation: Restored ecosystems provided better habitats for plants and animals. Biodiversity has increased as a result of ecological restoration. It is estimated that the project created a total value of 349 million yuan in biodiversity conservation.

Windbreaks: The Kubuqi Desert is situated close to Beijing and is the main source of sandstorms in the Beijing–Tianjin–Hebei region. It is often called “a pot of sand suspended over the head of Beijing”. Large-scale desert reforestation has greatly reduced the frequency of sandstorms in the region. Along the south bank of the Huanghe River, Elion planted 3,500 km² of windbreak trees. The economic value of the windbreaks (in terms of erosion and sandstorm control) is estimated at 7,642 million yuan.

Water Resource Conservation: Re-established vegetation in the desert has played an important role in improving the hydrological cycle and increasing the ability of ecosystems to conserve water resources. It is estimated that the project has created a total value of 24,376 million yuan in terms of water resource conservation.

3.2.5 Financial Return

Elion's direct financial return comes from vegetable and fruit production, the culture and processing of medicinal plants, the production of green fodder, food and medical products, eco-tourism, green energy, landscape engineering and other related business operations. During the early stages of ecological restoration, the costs were higher than the profits. The project only became profitable after nearly 20 years of implementation. According to

Elion's financial report, the total monetary assets of Elion has reached 100,000 million yuan. The financial report also showed that the company achieved a 3-8 per cent return on equity, and an approximate 60 per cent asset to liability ratio, indicating the business is in good health.



3.2.6 Total Wealth Creation

Table 1 shows the total wealth created from Elion’s ecological restoration business. The total accountable wealth reached 500,863 million yuan, equivalent to US\$ 72,589 million.

Table 1 Summary of wealth created by Elion’s Kubuqi business model

Type of wealth	Examples	Achievements	Value (mil. yuan)
Inspirational Return	Hope for the future	Stakeholders are inspired by a brighter future	
	Leadership	Leadership skills are developed for long-term commitment	--
	Ecological culture	Development of eco-culture	--
	Indigenous culture	New villages are built and locals lead a happier life	--
Socioeconomic Return	Poverty alleviation	Per capita annual income increased from 747 to 17,000 yuan in project period (average annual increase of 11.5 per cent) for the population (100,000) in the project area. Based on a social survey, Elion contributed about one third of the annual growth, the total addition to local incomes is 8,400 million yuan.	8,400
	Research and development	Patented 243 technologies; new technologies saved reforestation costs of 2 billion yuan	3,161
	Social security	Better access to education, medical care and transportation	--
Green Land Return	Value added to land	Reclaimed 6,458 + 850 km ² of land and 4,475 km ² is currently under restoration	345,721
Ecological Return	Carbon sequestration	Sequestered 14.5 million tons of carbon	4,204
	Oxygen production	Produced 18.3 million tons of oxygen	6,762
	Biodiversity conservation	Improved habitats for plants and animals	349
	Windbreaks	Established 5,391 km ² of windbreaks	7,642
	Water resource conservation	Improved hydrological processes	24,376
Financial Return	Total monetary asset of Elion		100,000
Total			500,615



4. Knowledge-Sharing and Recommendations

4.1 Lessons Learned

In most countries, ecological restoration is usually carried out through public investment. Private companies might be involved in ecological restoration projects as contractors, but rarely as investors. To date, most of the well-known ecological engineering projects – such as the Roosevelt Prairie Forestry Project (USA), the Stalin Transform Nature Plan (the former USSR), the Green Dam Project (5 countries in North Africa) and the ‘Three-North’ Shelterbelt project – have been initiated by governments. Only a few large-scale ecological restoration projects have been initiated by the private sector. Elion’s Kubuqi business model for the restoration of desert land is one of the notable success stories. The key lessons learned from Elion’s experiences are summarized as follows:

1. An effective business model – PPP+: Elion Resources Group ventured into land reclamation in the Kubuqi Desert in 1988. Through its innovations in business operation, cooperative models and technical development, Elion has established a comprehensive system for the restoration of large-scale degraded ecosystems. Elion manages its ecological restoration business through an extensive network of stakeholders, including private organizations (Elion itself), the public sector (the Government), people (local communities), and scientific and international communities, which together form a unique PPP+ business cooperation model. Under clear land tenure arrangements with local communities and favourable policy support, the private sector can make better use of its financial investments and technological knowledge for the implementation of ecological restoration projects. Elion developed an effective mechanism for building a fair partnership with local communities: an agreed land tenure arrangement

and employment opportunities for the local population – enabling them to increase their income generation. In the broader policy context, the local government plays an important role in ensuring stable policy implementation and supports the private sector in accessing public resources, including funding. At the same time, it is also important to engage the scientific and technological community for technological support, and international organizations for better knowledge-sharing.

2. Beneficial socioeconomic returns strengthen the PPP+ partnership: The successful execution of the ecological restoration of large-scale degraded ecosystems created a wide range of returns (or benefits) to all stakeholders. In addition to financial returns, the projects generate a wealth of socioeconomic returns. For example, the value added to land resources become the key driver of regional economic development. Moreover, income generation improves the livelihoods of local communities and taxes improve the local government's finances. Improved ecosystem quality, on the other hand, created rich ecological wealth, including biodiversity conservation, water resources conservation and carbon sequestration, benefiting the region and the world. Therefore, all stakeholders received their returns from participation in ecological restoration activities, ensuring their continued engagement.
3. A smart business structure ensures sustainable operation: The length of time it takes to generate financial returns on investment in ecological restoration businesses is a major drawback for private sector investors. They cannot be successful without a smart business structure. Elion started as a salt chemical company and gradually moved fully into ecological restoration. The salt chemical industry provided financial support to Elion in the initial stages, enabling the company to survive before generating profits from its ecological restoration operations. Thus, a business structure that combines both short-term and long-term returns on investment is particularly important during the early stages of business development. Commonly,

ecological restoration businesses require a minimum of 20 years before they start generating a stable profit. Therefore, having a smart business structure from the outset is a prerequisite for sustaining business operation in the long-term.

4. Scaling up using adaptive replication to expand impacts: Ecological restoration is complicated, both in terms of operational mechanisms and technological innovations. In addition, variations in the socioeconomic context and the policy environment add to the complexity. Therefore, any 'best practice model' should be adaptable and replicable so that it can be scaled up. Elion tested its business model outside the Kubuqi Desert, including sites in Xinjiang Uygur Autonomous Region, Hebei Province, Gansu Province and provinces in the southern part of China. The scaling up exercises promoted Elion's innovations in collaboration and business operation to ensure they were appropriate for the new socioeconomic and policy context. It is crucial to remain flexible in strategic development decisions in order to scale up, adapt and replicate.

Behind the success of Elion's ecological restoration business, were challenges throughout the developmental process. In the beginning, it was difficult to engage local communities because they did not believe that "planting trees is possible in the desert". This is because the local communities had been trying to plant trees in the desert for many years under governmental initiatives, but had failed. There was limited government support due to a lack of public finances and limited financial resources to support such projects while China was opening up its economy. Thus, great efforts were made to increase agricultural production. In addition, the lack of technological support was a challenge. Under these circumstances, Elion had to demonstrate it was capable of functioning on its own. It rose to the challenge and through its technological innovations, the survival rate of planted trees has gradually increased.

There were also challenges in terms of balancing the

books. Ecological restoration is an expensive investment and initially there was little sign of any direct financial return in the company's accounts. Profit is the key indicator of a successful private business operation and a condition for its sustainable development. During the early days, finding ways to turn investment in ecological restoration into a profitable business was a constant challenge. Selecting plant species with economic value became a crucial technical assignment for Elion staff. For this reason, licorice (*Glycyrrhiza uralensis* Fisch), a locally distributed medicinal plant, became the focus of Elion's ecological restoration plan. It is a valuable medicinal plant, highly adapted to the desert conditions and capable of improving the soil because of its nitrogen-fixing capabilities. Large-scale licorice plantations were established under various tenure arrangements with local communities, opening up new business fields for Elion. In addition, Elion made great efforts to explore other business opportunities based on the desert ecological restoration project, including fodder production from willows.

There were limitations as well. There is no doubt that the direct financial return to a private company can be very low, even though the total wealth created is great. Moreover, incentives for private sector organizations to engage in ecological restoration businesses are limited. In Elion's case, one of the key elements was the motivation of the leadership. The Chair of Elion, Mr. Wang Wenbiao, was born in Kubuqi and had experienced the difficulties of living in such harsh conditions. From an early age, he had dreamed of building an oasis in the middle of the desert. At key stages, his personal influence and ambition played a major role in sustaining the development of the ecological restoration business.

4.2 Recommendations

Elion is probably the only large-scale ecological restoration business in the world that has such a long-term vision. Over 28 years, Elion has accumulated total financial assets of 100 billion yuan, while the socioeconomic and ecological return is estimated at 400 billion yuan – nearly

4 times the direct financial return. These value-added returns have contributed to poverty alleviation, regional economic development, biodiversity conservation and the reduction of greenhouse gas emissions at the national and global level. Ultimately, Elion has built a new world in the desert, improved the land and established a platform for different partners to open businesses in Kubuqi. It is hoped that Elion's success story will encourage more private companies to develop partnerships to achieve the UN Sustainable Development Goals, particularly the implementation of Goal 15 (protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss).

Elion's business model and experience in ecological restoration highlight several key elements. As discussed in chapter 2 and chapter 3, successful implementation of ecological restoration of large-scale degraded ecosystems is a complicated process, which involves a variety of elements, ranging from a viable business model that adapts to the biophysical and socioeconomic conditions, to an enabling policy environment that supports sustainable business operation over a prolonged period of time. Thus, the scaling up, adaption and replication of Elion's Kubuqi business model requires policies that support the following elements:

1. A predictable land tenure regime: The land tenure regime varies from region to region. Ecological restoration of large-scale degraded ecosystems usually involves large land areas with complicated land tenure systems. In most cases, the landlords of degraded land practice informal land tenure arrangements, such as common land and collective ownership arrangements. Therefore, it is important that the government regulates policies to ensure a predictable land tenure regime for a set period so that the private sector can predict changes in land ownership, and a clear division of benefits can be set among stakeholders.
2. Business incentives for the private sector: Because of the nature of the ecological restoration business,

a private company usually needs alternative business opportunities to thrive and sustain its operations. Therefore, it is important to have policies that promote access to alternative business opportunities at the local level, including getting access to lower financing opportunities.

3. Mutually-beneficial partnerships: Partnerships play a crucial role in ecological restoration projects. Policies should allow and encourage all stakeholders to engage in ecological restoration processes and benefit from the activities. The roles of the key stakeholders may vary according to circumstances, but in a comprehensive ecological restoration project, the government, the private sector and local communities are all key stakeholders. Participation of technical communities and non-governmental organizations is important for providing technological support, as well as information sharing and dissemination.
4. Innovation, long-term vision and planning: Innovation is the key to success, while a long-time vision and planning is a prerequisite for ecological restoration. Private sector organizations often lack a long-term vision in their strategic planning as they are often susceptible to changes in the policy environment. A stable policy regime is an essential precondition for enabling the private sector to plan for the long term.

In summary, Elion's Kubuqi business model has great potential for adapting, replicating and scaling up in other parts of China and the rest of the world. Following its successful implementation in the Kubuqi Desert, Elion has started to replicate its model for the restoration of degraded ecosystem in other regions in China, including in Hebei, Xinjiang and Gansu Provinces. The knowledge gained from ecological restoration projects as well as the materials collected (over 1,000 planting materials suitable for desertification control) are valuable resources. Elion is ambitious and is making great efforts to share and publish its experiences and knowledge with the world through a variety of different channels.



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Annex

This appendix further explains the four types of returns qualitatively and quantitatively (Chen et al., 2003; Chen et al. 2006; Zhao et al., 2004).

Inspirational Return

Restored ecosystems help inspire local communities, governments and other key stakeholders, through improvements to the aesthetic environmental/landscape, spiritual enrichment and cognitive development. Restored ecosystems also improve the confidence of the local community in restoration activities, encouraging future engagement; and enhance their understanding of the importance of environmental protection. Inspirational return is an abstract concept and is difficult to assess using quantitative methods.

Socioeconomic Return

Socioeconomic return includes elements that promote the social development of local communities, including improved infrastructure (e.g. transportation and health care) and knowledge – both of which are key for innovative development.

Similar to inspirational return, most socioeconomic return is difficult to assess quantitatively. However, the economic value of poverty reduction and knowledge generation can be calculated. Poverty reduction is based on the assumption that 30 per cent of the increase in income can be attributed to the project, and the value of knowledge generation is based on the value of patented technologies:

where:

V – total value (yuan)

P – average market price of patents (yuan/patent)

Q – number of authorized patents

For technologies that are widely applied in production, economic value can also be estimated from the reduction in total costs or the increase in production, in comparison to the use of traditional technologies.

Green Land Return

Ecological restoration improves the quality of the land; the added-value can be calculated as follows:

$$V = A \times P$$

where:

- V – total value of land (yuan)
- A – area of reclaimed land (km²)
- P – land price (yuan/ km²)

The total area of restored land in Kubuqi is 11,000 km², including 6,236.95 km² that has been fully reclaimed and 4,763.05 km² that is currently under reclamation. The restoration areas in Zhangjiakou, Kerqin and Shanghaimiao are 255.20 km², 33.33 km² and 278.58 km², respectively. In this report, the land price of level I industrial land is determined by the local Bureau of Land and Resource. In the afforested area in Kubuqi, the land is valued at 30 yuan/ m², which is determined by the Baiyanhua Town, Xixiaozhao Town and Xianfeng Town in Bayannaoer Banner,¹ while non-afforested land is valued at 60 per cent of the price of land in the reclaimed area. The price of land in Zhangjiakou² is 194 yuan/m²; in Keerqin³ it is 22 yuan/m²; and in Shanghaimiao⁴ it is 76 yuan/m². The total land value is calculated by adding the land value of all four restoration areas.

Ecological Return

This includes the increased value of natural resources and ecosystem services, such as carbon sequestration, oxygen generation, biodiversity and water resource conservation. The methods employed to estimate their economic value are as follows:

Carbon Sequestration (Fan et al., 2013; State Forestry Administration, 2008; Mu et al., 2013; Wang, 2012; Piao et al., 2001; Zhu et al., 2007)

$$M_{a,i} = 1.63 \times R \times NPP_i \times A_{a,i}$$

$$M_b = \sum_{i=1}^n M_{b,i} - M_0$$

where:

- V – total value of carbon fixation (yuan)
- C – cost of industrially- produced carbon, 273.3 yuan/t
- M_i – amount of carbon fixation in the i^{th} year (tC)

1 http://bynr.nmggtt.gov.cn/zwgk/dj/jzdj/201507/t20150724_411354.html

2 http://www.ml.gov.cn/tdsc/land/crgg/qtyd/201406/t20140606_3167399.htm

3 http://chifeng.nmggtt.gov.cn/cfaq/zwgk/jzdj/201508/t20150831_419897.html

4 http://ordos.nmggtt.gov.cn/eeqq/zwgk/jzdj/201408/t20140825_243551.html

$M_{a,i}$ – amount of carbon fixation through vegetation in the i^{th} year (tC)
 R – percentage of C in CO_2 (27.27%)
 NPP_i – net primary productivity of vegetation in the i^{th} year ($\text{t}/\text{hm}^2/\text{a}$)
 $A_{a,i}$ – area of reclaimed land (hm^2)

M_b , M_p , M_o are the total amount of carbon fixed through the soil, the amount of carbon fixed through the soil in the i^{th} year and the original amount of carbon in the soil, respectively (tC).

A remote sensing-based Collaborative Adaptive Sensing of the Atmosphere (CASA) model was used to evaluate the NPP of vegetation:

$$NPP(x,t) = APAR(x,t) \times \varepsilon(x,t)$$

where:

$APAR(x,t)$ is intercepted photosynthetically active radiation at a grid cell (x) in month t ($\text{gC}\cdot\text{m}^{-2}\cdot\text{moth}^{-1}$)
 $\varepsilon(x,t)$ is light utilization efficiency ($\text{gC}\cdot\text{MJ}^{-1}$)

$$APAR(x,t) = SOL(x,t) \times FPAR(x,t) \times 0.5$$

where:

$SOL(x,t)$ is the total solar radiation incident on grid cell x in month t , $\text{MJ}\cdot\text{m}^{-2}\cdot\text{moth}^{-1}$ $FPAR(x,t)$ is the fraction of the incoming PAR intercepted by green vegetation

$$FPAR(x,t) = \frac{(NDVI(x,t) - NDVI_{i,\min})}{(NDVI_{i,\max} - NDVI_{i,\min})} \times (FPAR_{\max} - FPAR_{\min}) + FPAR_{\min}$$

where:

$NDVI_{i,\max}$ – maximal NDVI of vegetation type i
 $NDVI_{i,\min}$ – minimal NDVI of vegetation type i
 $FPAR_{\max}$ and $FPAR_{\min}$ – area 0.001 and 0.95

$\varepsilon(x,t)$ is estimated as follow:

$$\varepsilon(x,t) = T_{\varepsilon_1}(x,t) \times T_{\varepsilon_2}(x,t) \times W_{\varepsilon}(x,t) \times \varepsilon_{\max}$$

where:

$T_{\varepsilon_1}(x,t)$ and $T_{\varepsilon_2}(x,t)$ account for the effects of temperature stress, $W_{\varepsilon}(x,t)$ accounts for effects of water stress, and ε_{\max} is the maximum possible efficiency

$$T_{\varepsilon 1}(x, t) = 0.8 + 0.02 \times T_{opt}(x) - 0.0005 \times [T_{opt}(x)]^2$$

where:

$T_{opt}(x)$ is defined as the air temperature in the month the NDVI reaches its maximum for the year

$$T_{\varepsilon 2}(x, t) = 1.184 / \left\{ 1 + \exp \left[0.2 \times (T_{opt}(x) - 10 - T(x, t)) \right] \right\} \times 1 / \left\{ 1 + \exp \left[0.3 \times (-T_{opt}(x) - 10 + T(x, t)) \right] \right\}$$

Where:

$T(x, t)$ is the mean monthly temperature

$$W_{\varepsilon}(x, t) = 0.5 + 0.5 \times E(x, t) / E_p(x, t)$$

$E(x, t)$ is the practical evaporation (mm), and $E_p(x, t)$ is the potential evaporation (mm)

Oxygen Provision (Fan et al., 2013; Mu et al., 2013; Wang, 2012; Piao et al., 2001; Zhu et al., 2007)

where:

V – total value of oxygen provision (yuan)

C – cost of industrial producing oxygen, 369.7 yuan/t

U_i – amount of oxygen releasing by vegetation in the i^{th} year (t/a)

$$U_i = 1.19 * NPP_i * A_i$$

NPP_i is net primary productivity of vegetation (C/m²·a), A_i is the area of reclaimed land (km²)

Biodiversity (Xie et al., 2003)

$$V = A \times p$$

where:

V – Value (yuan)

A – area (km²)

P – modified service value of unit area (yuan / (km²·a))

p is modified with biomass and Shannon-Wiener index:

$$p = \frac{h}{H} P$$

Where:

h_i – Shannon-Wiener index at time i

H – Shannon-Wiener index of semi-arid grassland ecosystem (2.6)

P – Service value of ecosystem per unit area in semi-arid grassland ecosystem $P=6890$ yuan/km²·a)

Windbreak (Zhao et al., 2004)

$$V = \sum_{i=1}^n A_i \times E_s$$

$$E_s = A_w \times B \times 100 / (H \times \rho)$$

Where:

V – total value (yuan)

A_i – accumulated area of afforestation at the i^{th} year (km²)

E_s – opportunity cost of the soil (yuan/km²·a)

B – average profit of animal husbandry production (yuan/hm²·a)

H – average depth of cultivated soil layer(m)

ρ – volumetric weight of soil (kg/m³)

A_w – amount of soil prevented from wind erosion (t/(km²·a))

Water Conservation (Jiang, 2003; Si et al., 2011; Nie, 2009; Yearbook of China Water Resources, 1999)

$$V = \sum_{i=1}^n Q_i \times C$$

$$Q_i = A_i \times B$$

where:

V – total value of water conservation (yuan)

Q_i – amount of conserved water resources in the i^{th} year (m³)

C – construction cost of reservoir (yuan/ m³)

A_i – area of plantation established in the i^{th} year (hm²)

B – average capacity of water conservation by plantations (m³/hm²)

Financial Return

Financial return is the total profit generated from the ecological restoration business. It is estimated based on the financial data obtained from the operators.

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