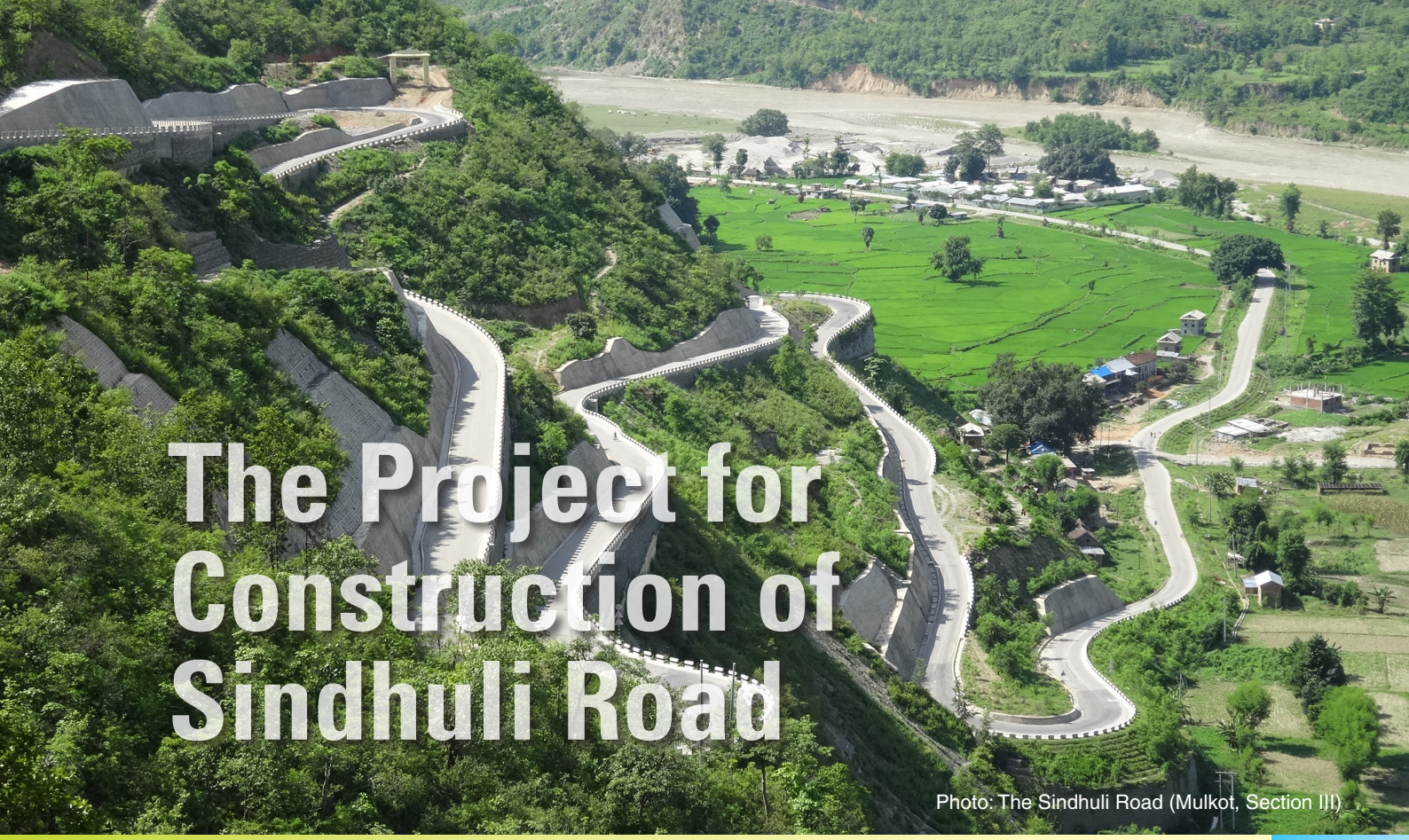

The Project for Construction of Sindhuli Road

Photo: The Sindhuli Road (Mulkot, Section III)

Reasons for taking up this project

The Sindhuli Road is a 160 km long highway constructed in Nepal with the grant aid assistance by the Government of Japan. By connecting Kathmandu, the capital of Nepal, and the Terai plain that leads to India, the Sindhuli Road was constructed with the aim of shortening travel times and securing a stable transportation route for goods, thereby contributing to the stability of logistics, industrial development, as well as to improve the livelihood of residents along the road. The construction work started in November 1996 and was completed in March 2015, taking nearly 20 years.

As a grant aid project with Official Development Assistance (ODA), the project has the following outstanding features worth being recorded in JSCE archive.

1) The Sindhuli Road project is the one and only project to construct a totally new road (there is no another project that is a completely new construction, with other projects either aiming at the improvements or widening of an existing road). The project paved the way for a road in a hill area of Nepal where no road had existed before.
2) One of the largest grant aid projects by Japanese ODA with a total of about 26 billion yen committed.
3) Construction sites had to overcome difficulties such as the worsening security under insurgency situation and the risk of disasters. In about 30 years from the initial survey in 1983 to the completion of construction work in 2015, Nepal experienced unstable political climate including democratization movements and insurgency by Maoists. Further, frequent large-scale natural disasters hampered the construction work.
4) Cost effectiveness was optimized by using local materials and technology suitable for the circumstances in Nepal, while considering the design to prevent the risk of landslides.
5) The project had a huge socio-economic impact on Nepal, and contributed significantly to the capacity building of individuals and companies in the civil engineering and construction industries in Nepal by providing trainings and opportunities to work on sites.

1 Project Background

Nepal is a landlocked mountainous country sandwiched between the two giants, India and China. The Himalayas rise high between China and Nepal, meaning many imported goods would land in Kolkata, India, and be brought into Nepal through roads within India. In Nepal, the first road that cars could drive on, Tribhuvan Highway was opened in 1956. This 114 km road from Luxor, the trading hub of India and Nepal, to Kathmandu, the capital, was constructed by the Indian Army. However it took time to travel over three mountain passes, including the Daman Pass at an altitude of 2,540 m. Following this, a road constructed with the assistance of China from 1974 to 1982 was used as a logistics route between India and Nepal, but this road was often closed and cut off due to landslides. It was Nepal's earnest wish to have an alternative road. The Sindhuli Road, which fully opened in 2015, was this alternative road that Nepal had been longing for.

The Sindhuli Road is a mountain road that sees the altitude fluctuate from 200 m to 1500 m above sea level. At the basic design stage, the Sindhuli Road was planned as a mountain pass road with no tunnel. Since there were no road tunnels in Nepal then, it was anticipated that tunnel management in the mountains was extremely challenging. The possibility of significant increase pf project costs after the start of the project was another reason to have no tunnel. Since the project would construct a new mountain road, there was a large amount of civil engineering work to cut and fill for stabilization of the slopes. Approximately 2.4 million cubic meters of soil was cut during the construction, approximately 1.4 million cubic meters of soil was filled, which is equivalent to about three Tokyo Domes (the largest baseball stadium in Japan). The amount of civil engineering work volume for the construction of structures to protect slopes and to build the road foundation was approximately 940,000 cubic meters. The total number of engineers and workers engaged in this major construction amounted to 5.8 million man-days (Table 1).

Heavy rainfall during the rainy season causes large-scale landslides and floods, due to active orogenic movement of Nepal's mountainous terrain and soil erosion caused by the people's livelihood activities. The construction sites were at risk of damage

Table 1: The Main Construction Volume & Number of Construction Workers for the Sindhuli Road

	Unit	Section I	Section II	Section III	Section IV	Total
Road distance	km	37	36	37	50	160
Earthwork	Thousand m^3	146	1,000	686	1,026	2,858
Concrete work	Thousand m^3	9	106	87	66	268
Gabion	Thousand m^3	36	122	120	28	306
Mortar masonry retaining wall	Thousand m^2		157	113	132	402
Total length of drainage work	km	8	48	56	74	186
Road paving with asphalt	Thousand m^2	14	170	180	289	653
Bridges	No.	9	1		5	15
		Steel bridges: 5, concrete bridges: 10, total length = 1,030 m				
Causeways	No.	5	3	12	19	39
		Box type: 14, overflow / perforated type: 25, total length = 2,390 m				
Total no. of construction workers		Consultants: 30, construction companies: 54, number of man-days of Nepalese workers = 5.8 million				

every rainy season. The Project actually faced a large-scale washout of completed sections, or the danger of the flooding caused by a dammed lake created by a landslide. Also, during the 20-year construction period, the civil war between the government and the rebel guerrillas (Maoists) continued for many years in Nepal, and the project had to overcome problems such as protective measures against the rebel guerrillas, safety management, and strikes as part of their anti-government activities.

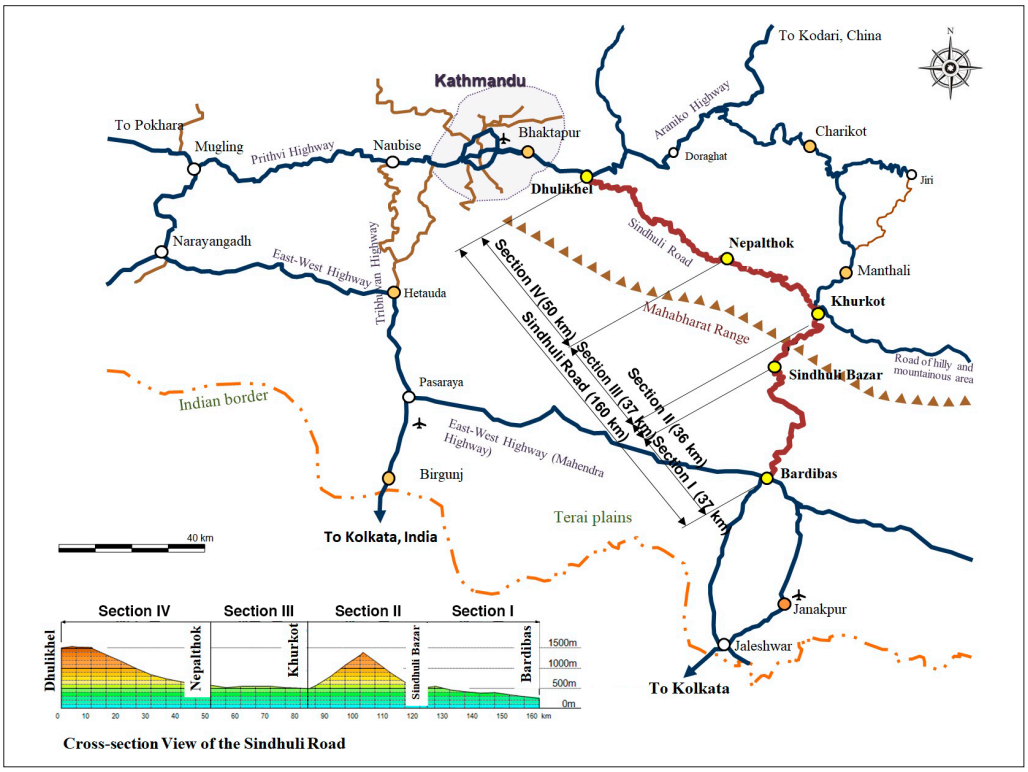

Figure 1: Project Map

2 Project Chronology

The first concept of the Sindhuli Road appeared during the Cold War era in the report of the Kathmandu–Janakapur Road Plan, prepared by the Regional Transportation Organization with the support of the United States and India, who were wary of the Soviet Union and China. In the 1970s, an Italian consulting firm also developed a road plan from Sindhuli Bazar to Dhulikhel, which was never materialized.

In the 1970s, Japan Overseas Cooperation Volunteers played an active role in development activities in Nepal and JICA started an agricultural project in the area around Sindhuli Bazar. Sindhuli Bazar was a town which would become the starting point of the Sindhuli Road on its south side. In order to market agricultural products, it was often pointed out that a road was needed to transport fruits and vegetables produced in the mountains to improve the livelihoods of the local citizens. Under such circumstances, heavy machinery for road construction was provided to Nepal by Japan in 1981. This was the first grant aid for the Sindhuli Road.

In 1983, a survey by the Infrastructure Development Institute Japan made a proposal for the construction of the Sindhuli Road.

Then in 1985, the Government of Nepal officially requested the Government of Japan to conduct a feasibility survey for the Project plan. In 1986, JICA started the 'The Survey on the Project for Construction of Sindhuli Road.' Although the survey was completed in 1988, Japan's assistance continued to be under review and only after another survey in 1993, an Exchange of Note on grant aid for road construction was signed in 1995. Affected by the deterioration of relations between India and Nepal and the democratization movement in Nepal, it took 10 years to conclude the first Exchange of Notes after the initial request from the Government of Nepal to the Government of Japan to conduct a survey. The Sindhuli Road was constructed by dividing it into four sections, section I from the south side (Indian side) to section IV on the north side (Kathmandu side). Financial assistance by the Government of Japan continued over 16 phases (Table 2).

Table 2: List of Grant Aid Projects for the 'Project for Construction of Sindhuli Road'

Section	Location	Distance	Approval Year	Project Name	Phase	Date of Exchange of Notes	Committed Amount (Thousand yen)
Section I	Bardibas to Sindhuli Bazar	37 km	1981	Project for Construction of Mahendra Rajmarga-Sindhuli Road Construction	-	1982/2/17	300,000
			1995	Project for construction of the Sindhuli Road Section I (Detailed Design)	-	1995/8/16	75,000
			1996	Project for construction of the Sindhuli Road Section I	-	1996/6/18	2,112,000
						Total	2,487,000
Section IV	Khurkot to Dhulikhel	50 km	1996	Project for construction of the Sindhuli Road (Section IV) (Detailed Design)	-	1996/9/3	118,000
			1997	Project for construction of the Sindhuli Road (Section IV)	I / II	1997/6/6	2,651,000
			1999	Project for construction of the Sindhuli Road (Section IV)	II / II	1999/7/6	2,011,000
			2003	Project for Emergency Rehabilitation of Sindhuli Road (Section IV)	-	2003/7/11	434,000
						Total	5,214,000
Section II	Sindhuli Bazar to Khurkot	36 km	1999	Project for construction of the Sindhuli Road (Section II) (Detailed Design)	-	2000/1/10	74,000
			2000	Project for construction of the Sindhuli Road (Section II)	I / III	2000/6/21	2,439,000
			2001	Project for construction of the Sindhuli Road (Section II)	II / III	2001/8/17	3,317,000
			2005	Project for construction of the Sindhuli Road (Section II)	III / III	2005/6/9	2,588,000
			2012	Project for Countermeasure Construction against the Landslides on Sindhuli Road Section II	-	2012/7/10	901,000
						Total	9,319,000
Section III	Khurkot to Nepalthok	37 km	2008	Project for construction of the Sindhuli Road (Section III) (Detailed Design)	-	2009/2/12	50,000
			2009	Project for construction of the Sindhuli Road (Section III)	I / II	2009/6/23	4,333,000
			2011	Project for construction of the Sindhuli Road (Section III)	II / II -1	2012/2/15	577,000
			2012	Project for construction of the Sindhuli Road (Section III)	II / II -2	2012/7/10	4,096,000
						Total	9,056,000
						Total amount	26,076,000

3 Project Features

3.1 Challenging Environment: an Arduous Construction in the Mountains

The Sindhuli Road was a new road constructed in a mountainous area that had no existing road whatsoever. Therefore, the consultant (Nippon Koei Co., Ltd.), who was in charge of design and construction supervision, and the workers of the construction companies (initially a joint venture between Hazama and Taisei Corporation, and later Hazama Ando Corporation) established a construction camp in a remote area, where all staff and workers stayed overnight for days. At the construction site in the mountains very far from any cities, a bulldozer was ploughing through the jungle and creating a spectacle that had hardly been seen at any other construction site. A concrete mixer-truck could not come deliver concrete, and all the materials had to be procured locally, mixed, checked for quality, and placed. Project members also shouldered the responsibility of procuring, delivering, maintaining and repairing the heavy machinery. Securing delivery of materials such as cement, steel, and diesel fuel in a timely manner was another task. The construction sites were on steep slopes, therefore, there were many challenges unique to geographical conditions. Such works, for instance, are the construction of a large temporary road only to deliver the equipment and materials, or the construction of scaffolding on steep slopes, and all of these activities were to be well prepared and sequenced so that the construction work would not delay.

Photo 1: Example of the Temporary Road (Center of Photo) (Section II)

Photo 2: Foundation Work at the Area with the Steepest Slope (Section II)

3.2 Risk of Natural Disasters

The Sindhuli Road is in a mountainous area vulnerable to landslides. Thus ‘proper measures against rainy season’ remained a constant challenge that engineers had to keep in their minds during the 20-year construction period. In June 1999, the second year of construction, section IV experienced the collapse of the raised embankment and landslides at the construction site due to heavy rain exceeding 145 mm/day. In October of the same year, the continuous rain caused landslides in 99 locations. The constant

Photo 3: Washout of the Road along the Roshi River

Photo 4: Foundation Work for Revetment Retaining Wall

delay of construction during the rainy season and catching up and recovery during the dry months continued for many years.

The torrential rain in July 2002 even destroyed and washed away some parts of the completed road in section IV. Fundamental restoration work was required in the section running along the Roshi River, with 138 locations suffering damage, 15 of which saw road washouts, and the revetment retaining walls were uprooted and either swept away or fell. Although the road was designed with high water levels in estimating standard from the last 50 years, the rainfall at this time recorded by the Kathmandu observatory was 169 mm in 24 hours, setting the highest record in its recording history, and the rainfall for three days at the Roshi River amounted to 312 mm. In recovery efforts, a protective structure was installed on the riverbed by fixing concrete blocks with a width of 6 meters and a thickness of at least 1 meter, and a revetment retaining wall foundation that can withstand a raging torrent was put in place. This experience was utilized in the subsequent design and construction of the project.

In 2014, during the last rainy season just before the completion of construction, the project also faced an unexpected threat of damage. At the beginning of August, heavy rain struck the Sindhupalchok District, northeast of Kathmandu, causing a major landslide on the Araniko Highway. The enormous amount of earth and sand, which disrupted the road for over 5 kilometers, crushed 20 houses, and killed 156 people, blocked the flow of the Sunkoshi River, and formed a dammed lake that was 47 meters deep, 300 meters wide, and 3 kilometers long. If this burst, it was predicted that the section III camp of the Sindhuli Road, 57 kilometers downstream, would be washed away. This nail-biting set of circumstances lasted for 37 days before the reservoir burst. Fortunately, however, it did not cause any major damage and no one was hurt.

3.3 Safety Management During the Civil War

On June 2, 2001, a major incident, which would rock the history of Nepal, occurred. That is the massacres of the Nepalese royal family. The then king, King Birendra and the queen, and 10 other royals were killed. It is said that Prince Dipendra, the eldest son of the king, shot the victims inside the royal palace and immediately attempted to commit suicide by shooting himself. Falling into a coma following his failed suicide attempt, the unconscious Dipendra inherited the throne. Dipendra, however, died three days

later, with King Birendra's younger brother Gyanendra taking the throne. Compared to King Birendra, who was popular amongst the citizens of Nepal, King Gyanendra and his prince were unpopular. Their coronation was not given blessing, and a few days later, clashing between protestors and the police resulted in a state of emergency. These events would provide a great opportunity for the Maoists, who were hiding underground at the time and had engaged in anti-government activities. Maoists of the Communist Party of Nepal, a political group formed in 1995, started the "the people's war," in 1996, which caused insurgency in the country. In 2000, the People's Republic was established by the Maoists, acquiring their power mainly in the mountainous rural areas of the Midwest, where infrastructure was underdeveloped and poverty rate was extremely high. Their military operation and influence expanded to the area along the Sindhuli Road, exerting a significant impact on the construction work.

In February 2002, a police station in front of the construction camp in section IV was attacked by Maoists, killing 16 police officers and seriously or slightly injuring 15 others. There were no construction workers at the camp facilities, thus direct damage was avoided. However the construction was inevitably forced to be put on hold, taking a month and a half to resume work after safety measures were implemented. The impact by Maoists on the project, however, was not limited to this one incident. There were Maoists among residents employed for the project, and it was simply difficult and impossible to avoid the influence of Maoists. If a Maoist political strike (known as 'bhanda') was called for, the construction would have been stopped. For example, during the three-year construction period of section IV, the number of days the construction was suspended by a bhanda reached 98. At that time, many of the infrastructure projects financed by the World Bank or the Asian Development Bank, which were in a similar situation, had to be suspended. However, the Sindhuli Road project was not suspended even though the construction was delayed or temporarily put-on hold. The project kept the construction on track by taking actions based on information obtained from residents through the Nepalese staff. The Project also drew up a 'Safety Measures Manual' that organized crisis management levels and measures to be taken in advance. Another reason why there was no destructive obstruction to the Sindhuli Road could be that Nepalese residents including Maoists, needed and longed for the Sindhuli Road.

3.4 The Socio-Economic Impact of the Sindhuli Road in Nepal

(1) Strengthening National Resilience

In Nepal, because of a high risk of blockage of roads and bridges due to large-scale landslides caused by its geographical condition and soil erosion, as well as heavy rainfall during the rainy season, the people have suffered from commodities shortages and price hikes due to the disruption of existing highways caused by such problems. The Sindhuli Road has reduced this risk and enhanced the resilience of the nation and its

Photo 5: Survey Team Checking the Damage Caused by the Earthquake (May 2015)

people's lives. When the Nepal earthquake struck in April 2015, the existing highways were closed, while the Sindhuli Road remained open and served as a logistics infrastructure.

(2) Impact on Nepalese Private Companies and Training Human Resources

The Sindhuli Road had an impact on the capacity development of many Nepalese individuals such as those of Nepalese construction companies, construction workers, and consultant staff in addition to officers and engineers of Nepal's government agency, Department of Roads. The accumulated man-days of local engineers and workers amounted to 5.8 million during the Project, which provided on-the-job training opportunities for many. Examples of such impacts are two local companies, which have grown into major domestic construction companies in the country. While grant aid supports capital investment for the development of infrastructure, it is also worth noting the aspect of capacity development of human resources and private companies of the partner country through its implementation.

(3) Infrastructure Stock Effects

The effects that can be obtained continuously and over the medium to long term after the development of the infrastructure, such as the effect of safety and security, improving the quality of life, increasing productivity, are called the 'infrastructure stock effects.' The construction of the Sindhuli Road has delivered the following stock effects to the surrounding area. One could even claim that the Sindhuli Road changed the sense of distance between the capital and the south of Nepal, giving 'options' and 'opportunities' to those who had no 'options' before.

1) Improvement of productivity: the area along the Sindhuli Road has witnessed the expansion of agricultural and commercial facilities. In addition to the better logistics for shipment of agricultural products produced in areas along the road, the construction of new shops for agricultural inputs and daily commodities, hotels, restaurants has expanded. Easier access to agricultural input materials necessary for production has contributed to increased productivity.
2) Improvement of the quality of life: The number of schools, hospitals, and clinics has increased significantly along the Sindhuli Road[*1]. Furthermore, along with the increase in household income[*2], the use of mobile phones, the installation of solar power generators for each household, and the installation rate of TV antennas have increased significantly, which represents improvements of the living standard in the area.
3) Increase in the demand for transportation in the region: Since 2015, when the entire Sindhuli Road was open, the amount of traffic has increased rapidly (20–30% every year), triggering further increase in the demand for transportation in the surrounding area. For this reason, the

Photo 6: Junar (a Type of Orange) Shipped Along the Sindhuli Road

*1 From 2012 to 2015, the number of schools along the road increased from 11 to 23, and the number of medical facilities increased from 1 to 11.

*2 A socio-economic household survey indicated that the total per capita production per year increased from 19,187 rupees to 39,102 rupees in the three years from 2012 to 2015.

Government of Nepal plans new projects to enhance the country's transportation capacity by widening the Sindhuli Road, with a part of the project is already underway.

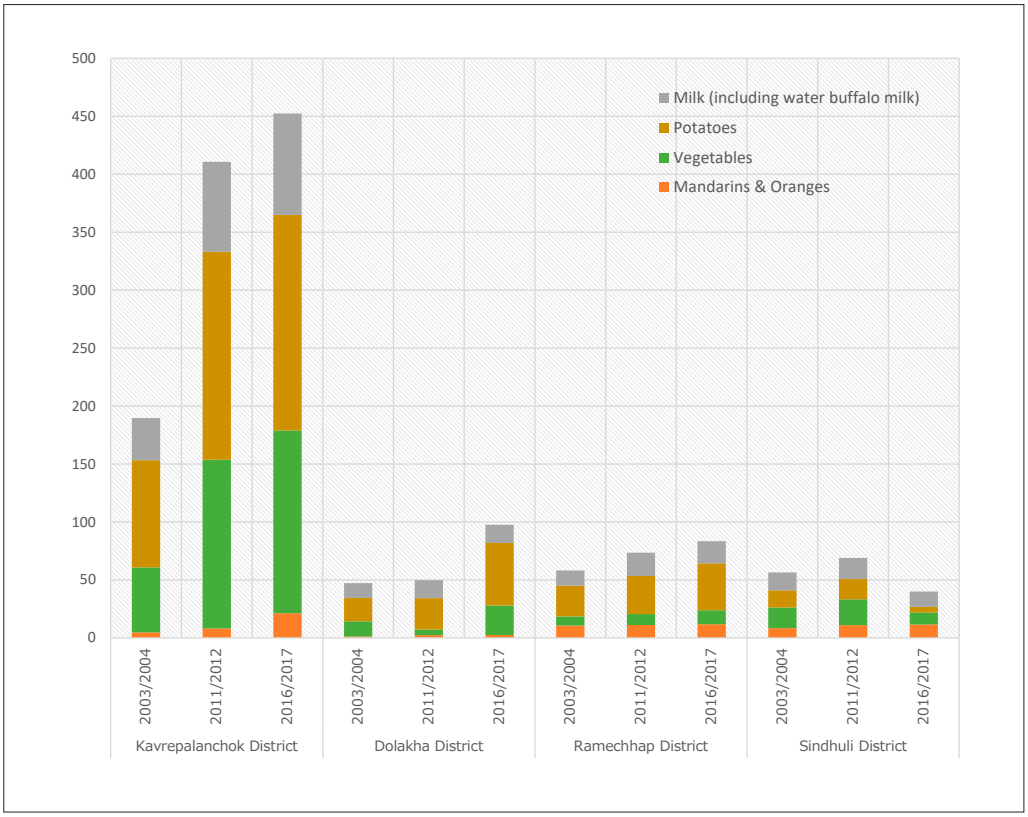

Figure 2: Changes in Agricultural Production along the Sindhuli Road (Source: Ministry of Agricultural and Livestock)

4 Lessons Leaned

4.1 Adoption of Cost-Effective Technology in Local Context

In the design of the Sindhuli Road, the use of locally available natural resources and the local labor force were maximized while cautious attention was paid to slope protection measures and drainage system. For example, the gabion retaining wall and the mortar masonry retaining wall both made use of stones that could be collected near the construction site. For the stones to be inserted into the retaining wall (filling stones), there was the advantage that the rocks removed from slopes cut during the construction could be used for this purpose. These construction methods were examined and adopted in section IV, where construction was started at the outset of the project, established a standard in the subsequent plans.

In section II where it was necessary to build a high retaining wall because the road runs along steep terrain, a geotextile reinforced wall was adopted. This new method was used in order to create a retaining wall that exceeded the height of 7 meters.

This construction method sees excavation up to the bottom of the foundation, and concrete placed, and then L-shaped panels with grid-shaped iron wires layered over the entire surface of the valley side. The wall is built up by connecting the reinforcement material (geotextile) while sandwiching the soil in between. This construction method, which does not require specific machines and additional resources from outside was adopted, because it can utilize excavated soil on the site and labor by local workers. This is a good example of adopting cost-effective technology in local context.

4.2 Passion, Dedication and Sense of Responsibility of the Consultants and Construction Companies

As mentioned in 3, there were many challenges such as construction in remote areas away from the capital, the risk of damage caused by natural disasters, and safety management during the civil war, however the 20-year long-term construction continued without suspension, leading to the opening of a new major highway for Nepal. The grant aid assistance is bilaterally tied in procuring contractors (though untied for subcontractors and companies from which materials and equipment were procured), and the same Japanese companies consistently engaged in the construction of the Sindhuli Road. In interviews with such stakeholders, they made comments like, "We will definitely get the work done on schedule. No excuses no matter what happens." and "There are times when I could say it can't be done and put down the tools, but Japan is different from other countries. We stick to the construction schedule even if the project is in financial loss." These statements express the consistent passion, dedication, and strong sense of responsibility from Japanese consultant company and construction company. Both parties were fully responsible for design and construction supervision, and the construction work. The project was successfully completed, because strong commitments of each person engaged in the Project from Japanese companies.

4.3 Key Persons on the Nepalese Side and Training of Human Resources

In addition to the consistent efforts of the Japanese stakeholders, there were also key persons who played an important role on the Nepalese side in the Project. Mr. Bindu Shamser Rana, Director of the Sindhuli Road Project at the Department of Roads, Ministry of Physical Planning and Works, Nepal, had obtained strong trust by many people involved in the Sindhuli Road. Mr. Rana, who served as the project manager for the first 15 years of the construction period contributed largely to the smooth implementation of the project. Mr. Rana was in position to be responsible for various works, such as approval of contracts, environmental and social consideration assessment procedures, inspecting defects, compensation, and managing the progress of the project. The contribution of Mr. Rana was huge, especially in the aspects where only a Nepalese person could do, such as handling security issues and the impact of the Maoists, and dialogue with from local residents, as well as decision making and approval process within the Government of Nepal. The training of staff in the Department of Roads was also carried out through JICA's technical cooperation and training

programs. Even after completion of the road, JICA has continued to provide technical assistance for maintenance management, resulting in significant improvements in road administration in Nepal.

Furthermore, the contributions of those at the Nepalese companies who carried out construction work on the site under the guidance of the Japanese companies cannot be overlooked. Among the individuals who were trained over the long construction period, there are several people who have developed from zero experience in the construction business to being the president of an outstanding company in Nepal. A person who started with "one bicycle and a pair of sandal" at the site of the Kulekhani power plant II in Nepal, who was hired by a Japanese general contractor (Hazama) later established a company and worked in various project with Hazama. Similarly, there is a former teacher from a poor family who participated in the construction and eventually became an entrepreneur to own a company and involved in the construction of a subway in Dubai undertaken by a Japanese company, sending 65 engineers, 50 technicians, and 2,400 workers from Nepal, and then worked his way up to becoming the chairperson of the Federation of Contractors' Associations of Nepal.

Many Nepalese who was trained through work on the Sindhuli Road now bear the responsibility of efforts for the growth and prosperity of Nepal. This impact, even though it is not the direct effect of the Project, is noteworthy.

Taking 40 years from its initial concept and 20 years for the construction, the 'The Project for Construction of Sindhuli Road' was realized with the continuous and consistent support of the Government of Japan and JICA, and it is built on the devotion of all the people who contributed to the Project in Nepal and in Japan. The Sindhuli Road represents friendship history of Nepal and Japan, and paved a way for future relationship of the two countries.

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Joined Japan International Cooperation Agency (JICA) in 1998, and served in a number of positions at JICA including Chief Representative of JICA Cambodia Office, Senior Director for Office of Gender Equality and Poverty Reduction, and Director for South Asia Division 3.
She authored the book on the Sindhuli Road, which was awarded the Book of the Year Award by Japan Society Civil Engineers in 2019.