Middle East • Iran

Saraman: Affordable Earthquake-safe Schools and Housing

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Executive Summary

With poverty comes vulnerability, and nothing exposes the vulnerabilities of people living in poverty more than natural disasters. To reduce construction costs, often unsafe construction methods and material are used to build houses. Corruption and lenient monitoring exacerbates this situation.

Population growth in developing countries accordingly asks for new safe homes and new jobs to address the coming generations of mostly low-income people in a situation where there is great emphasis on environmental sustainability. This might seem like a hopeless combination of too many challenging goals, but solutions are arising to address such challenges.

The profitable spin-off enterprise Saraman in Isfahan in central Iran, co-founded by an Iranian and a German professor, is an example of addressing housing and construction challenges in a profitable way. Moved by the shocking earthquake of Bam in 2003, realizing the problems of safety, inefficiency and cost of traditional constructions and seeing the opportunity of addressing the large baby-boom population of the 1980s whose need for safe and affordable housing cannot be met with conventional approaches, they decided to utilize state of the art technology in an inclusive and environmentally friendly way.

The company designs, fabricates and erects affordable, earthquake-proof prefabricated steel structures for houses, schools and hospitals. Through collaboration among German and Iranian universities and their corporate partners, state of the art technology is adapted to reduce cost and time of earthquake-proof construction, using locally available material in an environmentally friendly way. In addition, special training is provided to facilitate exchange of know-how and develop employment opportunities for young graduates who later implement the practice in Iran. So far about 400 Iranian students, scholars and experts participated in annual DAAD summer schools at the University of Wuppertal (BUW) in Germany.

By using modular design, safety-related skill-intensive parts are separated and prepared by skilled workers; hence the rest of the work can be assigned to jobless low-skilled workers without concern about safety and quality. Saraman currently has a team of 12 permanent employees and more than 65 temporary ones. Many more jobs are created for the lower-income communities who directly or indirectly engage in the construction projects. In the last two years, since Saraman moved from the know-how development phase to the commercial phase, more than 27 projects, mostly schools and other public constructions, with a total turnover of about 3.2 million Euros (US$3.9 million), have been awarded to Saraman.

As a stepping stone, Saraman started with public constructions, especially schools—which are teaching examples to civil society on how to build easily verifiable earthquake-safe buildings. With the awareness they created and the reputation they gained in public construction, they aim at entering the mainstream market of earthquake-proof housing.
Introduction

“Housing creates jobs, thus solving two problems at the same time.”
Professor Georg Pegels, German co-founder of Saraman

Housing is a major challenge for the rising young population of developing countries. Economic fluctuations and high unemployment among the youth have more severe effects in developing countries and add to the complexity of lack of housing. Rising prices of land and houses, makes it more and more difficult for those in low-income and lower-middle income groups to fulfill the dream of having proper accommodation. More over, there is a correlation between poverty and affordable quality of housing. This is evident when one compares the 2010 earthquakes in Haiti and Chile. Even though the 8.8-magnitude earthquake in Chile was 500 times stronger than the 7.0-magnitude earthquake that rocked Haiti, the scope of damage was significantly less. Chile has been able to take into account the effect of earthquakes and designing for them since the beginning of the 20th century. It is one of the most developed countries in South America. Haiti, on the contrary, is the poorest country in the Western Hemisphere and has rather weak construction practices.1

For households who have their dwelling as their main asset and shelter, the robustness of the construction is crucial. Add to that the fact that earthquakes alone don't kill people but collapsed buildings do. But the challenge, especially in low-income markets, is that using conventional construction methods is not only insufficient to ensure earthquake safety but also further increases the construction costs due to their inefficiencies.

Two academic entrepreneurs, one German and one Iranian, decided to address the challenge of affordable earthquake proof construction in the developing world using state of the art technology. Their effort demonstrates how a combination of advanced technology, transfer of know-how, training and local adoption using local resources and capacities can pave the way for new solutions. Effective use and implementation of technology speeds up the production process, hence reduces the construction time and saves costs making products affordable. Such technologies address a major problem facing housing in earthquake prone developing countries where high costs of construction, fraud and ineffective monitoring systems give way to construction of unsafe and low-quality houses. Such low-quality houses are like time-bombs that destroy the life of the poor with the trigger of an earthquake.

However, lessons from decades of technology transfers show that problems in the South do not automatically get solved by importing a new technology. Understanding local conditions and building absorptive capacity to adopt, implement, maintain and scale up the technological solution is critical. Developing know-how and training local young graduates are the key factors driving the successful development of Saraman. This case illustrates how such an

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approach was pursued to provide affordable earthquake-proof construction in an earthquake-prone country with the rising young population who need houses and jobs.

**Market and Location Context**

Iran is the 18th largest country in the world in terms of area at 1,648,195 km² with a population of about 70 million, of which 67% is urban. Much of the country consists of a high central plateau ringed by mountains and major faults cross at least 90% of the country. Iran has a long history of disastrous earthquake activity. Not only have these earthquakes killed thousands but they have also lead to waste of valuable natural resources. Since 1900, at least 126,000 fatalities have resulted from Iranian earthquakes. According to a former UN Resident Coordinator in Iran, Mr. Frederick Lyons, Iran has reported the highest number of deaths from earthquakes during 1980 and 2000 and in terms of the average number of people killed per million inhabitants per year, it ranks second in the world.

Among the Middle Eastern countries, Iran has experienced one of the fastest urbanization periods. Due to a baby boom in the early 1980s and rural-urban migration, during the last decade, just the urban population has increased by 11 million. This has created a challenge for urban housing, especially since it is coupled with increased urban poverty level. Different estimates indicate that 20% to 40% of the urban population lives below the poverty threshold. Unemployment rate is estimated at 20%.

**BAM EARTHQUAKE, AN ALARMING EXPERIENCE**

The latest major earthquake in Iran took place in 2003 in the city of Bam, resulting in the highest casualty rate and the most profound social impact in the recorded post-1900 history of devastating urban earthquakes in Iran. To illustrate how poverty and severe effects of earthquakes go hand in hand, it might be worth noting that during the same period, the area suffered from an unemployment rate of 25%, and 10% of the population earned less than one US dollar a day. The direct economic losses of the earthquake were estimated at US$1.5 billion.

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billion. In addition, the earthquake caused approximately US$53 million in agricultural loss, US$30 million in tourism, US$15.8 million in industrial loss, and US$1.3 million in private business loss. The indirect economic losses due to the destruction of houses and loss of jobs have not yet been estimated or reported. Widespread failure of poor-quality buildings has been cited as the major reason behind so many casualties in the area. Almost all who died during the earthquake were killed in buildings less than 30 years old.

CONSTRUCTION CHALLENGE AND HOUSING MARKET

In Iran, housing has a very low state capital share and the majority of investment is done by the private sector. At the same time, because of high construction costs, rapidly rising land costs fueled by inflation and dubious monitoring practices, construction projects tend to reduce expenses by bypassing the safe construction measures when they find a possibility to do so. Constructors interviewed about this obvious safety problem frequently answered: “Everybody cuts cost this way. I would not be competitive not using these opportunities.” On the other hand, Saraman proves that building safe construction can be profitable, provided that proper technology is used efficiently and in a systematic way.

Average construction life in Iran is 30 years, which reduces the economic value of the construction. Seventy percent of the houses are vulnerable to earthquake; thus Iran’s geographical position over a seismic belt necessitates the renovation of the construction sector and the building of earthquake-proof houses. This requires a boom in real-estate development, foreign investment and use of advanced technologies.

There is a severe housing shortage as each year about 800,000 new families are formed, but only around 450,000 housing units are built. Iran needs to build over one million housing units annually, but this has not been achieved yet. Another major issue is the rising price of accommodation, which is a big burden especially for lower income households. At present, the average price of a housing unit in urban areas is about ten times the annual income of an urban household. Average construction cost for 1m² of urban residential building in the first half of 2008 was US$350.

Earthquake-proof constructions are mandated by law in Iran. However, experts who visit Iranian construction sites will observe frequent and obvious contradictions between the regulation and actual practice. This is mainly due to fraud in the construction sector, which is at times facilitated by lenient monitoring.

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11 ibid
13 ibid
Business Model Formation and Development

Conventional construction technologies as applied in Iran are systematically unsafe and inefficient. Examples of such unsafe issues are fabrication on site without precise machines, welding on site when the inert gas is blown away by the wind, big tolerances preventing to get all bolts of a joint in, lack of inspection capacity, lack of vocational training, proof engineers not updating their certifications, lack of insurance paying in case of defects documented, and lack of contractual penalties observed.

When the German professor, who co-founded Saraman started to evaluate the chances of a start-up construction enterprise in Iran, he found the following inefficiencies and gaps in conventional construction approaches:

- Iranian construction enterprises have not invested in product development and innovative technologies for a long time.

- Designers generally invest no time to forethought and ease up production, erection and maintenance aspects of construction in their design. Designers therefore are ‘money burning’ in an exhaustive way.

- There are no expert workers to eliminate errors and cost of solutions the designer has specified.

- Efficiency of state-owned enterprises is very low and day-to-day errors are frequent in different phases of construction. Private sector is slightly better, but has not invested in vocational training. Therefore the limited modern machines they possess have not been used appropriately.

Considering the abovementioned inefficiencies, technologies that systematically ensure quality and safety by adapted technology transfer would be a promising approach that not only makes construction more efficient but also reduce the overall cost of construction.

The profitable spin-off enterprise Saraman in Isfahan, central Iran, co-founded by an Iranian and a German professor, is an example of addressing the challenges of earthquake-safety housing in Iran in a profitable way. Isfahan is situated well; he Iranian steel mills are at hand, young educated academics, welders, laborers and erectors are looking for jobs, and all of Iran is accessible by motorways of sufficient quality. A school built near the Afghan border by Saraman proves this accessibility.

Saraman produces affordable, earthquake-proof prefabricated steel structures for houses, schools and hospitals. Through collaboration among German and Iranian universities and their corporate partners, advanced construction technology is adapted to the Iranian context. It reduces cost and time of earthquake-proof construction, using locally available, cheap material in an environmentally friendly way. Cheap or free material, such as soft sun-dried adobe can be taken without risk, because the steel structure alone is designed to cope with earthquakes. This cost-cutting feature is essential to compensate for the cost of steel structures and deskill the assembly process to give a chance to jobless locals to help filling the structure.
onsite. In addition, special training is provided to facilitate exchange of know-how and develop employment opportunities for young graduates who implement the practice in Iran.

FORMATION
In the summer of 2003, the two professors met at an academic event in Germany. They were moved by the shocking earthquake of Bam that had happened few weeks before the meeting, and concerned with the inefficiency and low safety of traditional constructions exacerbated by fraud and faulty monitoring. They decided to utilize state of the art technology in an inclusive approach to address this.

Professor Georg Pegels, an academic entrepreneur and professor of CAD/CAM\textsuperscript{15} Technologies and Product Development in Civil Engineering at University of Wuppertal in Germany had developed technologies that would facilitate robust construction used in various European construction projects. He was eager to share it with those who need it most, namely construction industry in earthquake-prone developing countries. Professor Jamshid Parvizian, who is a professor of Industrial Engineering at Isfahan University of Technology in Iran and Director of its Entrepreneurship Center, had the ambition to turn the ideas into practice using the local young talents in the university. These young local talents would be vital for adoption, implementation and dissemination of advanced construction technology in the region.

Searching for possibilities of doing something about the construction situation in Iran, they had a market fact-finding mission in 2004 jointly with successful Iranian entrepreneurs and investors visiting for some weeks Iranian and German construction industries and analyzing their products, markets and customers satisfaction. They realized the opportunity of addressing the large baby-boom population of the 1980s whose need for safe and affordable infrastructure including schools, hospitals, sport halls and housing could not be met with conventional approaches. They identified two main challenges:

1. Population growth asks for new homes; a million per year in Iran alone.
2. Population growth asks for new job opportunities including construction as main resource; a million per year at least, in Iran.

The German professor recalled from post-war history of Germany, where similar severe housing situation and unemployment situation was addressed in an inclusive way.

\textbf{TRIGGER FOR INCLUSIVE MARKET: A LESSON FROM HISTORY}

As mentioned in the previous section, the young population in Iran faces the challenge of high unemployment and shortage of safe and affordable housing. The Building and Housing Research Centre (BHRC) of the Ministry of Building and Housing in Tehran analyzed this situation and found that about one million earthquake-safe homes per year has to be built in

\textsuperscript{15} Computer Aided Design/Computer Aided Manufacturing. CAD/CAM systems allow design of products using computers (CAD) and to store them in numerical (digitized) form, from which production machines can be controlled (CAM).
Iran. Saraman added the idea to use the need for housing in a way to simultaneously create job opportunities for the poor and on top of that, reduce negative environmental impacts compared to traditional construction methods and materials. The German co-founder of Saraman believed these challenges could indeed trigger an inclusive market, the way they did in Germany more than 60 years ago.

Directly after the Second World War, millions of people in Germany were poor, jobless and without a home. About 50% of the houses in towns had been destroyed and millions of refugees had fled to West Germany. This situation could be considered disastrous, but in fact it gave way to a hidden big-scale business model leading to what was later called German ‘Wirtschaftswunder’ (economic miracle). There was a huge market demand: new homes for millions. And there were millions of jobseekers. Policy makers and entrepreneurs in Germany started a national initiative boosted by international financial support to build millions of homes. This also created millions of job opportunities for the poor in building constructions. To build these houses, new construction equipment had to be produced. Consequently, more new job opportunities emerged in the industry sector. To make new construction equipment, new machine tools had to be fabricated, triggering more new job opportunities up to full employment.

Could the basic idea, the model of ‘Wirtschaftswunder’ be replicated and transferred by innovative adaptation to developing countries today?

GETTING THE BUSINESS IDEA

The two professors exchanged their views about the ambitious German model. But for implementing a housing solution they had to start with a small step; setting up a start-up company and finding an appropriate business model for it. They were in search of a proven model that could be used by a young start-up like Saraman.

Through Professor Pegels, they found an example to learn from; a German construction company called Goldbeck. It was a family-owned company that had been a start-up too. Thirty years ago it started with five employees. Now it has 2,400 employees. Its innovative construction and production solutions made Goldbeck a profitable market leader of Europe among family-owned construction enterprises. Goldbeck was known for its systematic production methods to gain superior efficiency and reliability by solutions well thought of beforehand in a product development group, which Professor Pegels joined regularly in his young scientific years. So, he knew why Goldbeck had grown profitably all the time when other construction enterprises in Germany had to give up by reducing employment in German construction from 1.6 million people to less than 800,000 persons today. The innovative business model of Goldbeck could be a solid guide for a start-up like Saraman even in very critical times.

The German co-founder considered the Goldbeck model to be adaptable and replicable in the Iranian context. By providing vocational training to employees, designers, industrial workers,
erectors and salesmen, as well as by investing in production lines and innovative technologies, there was a reasonable chance to become more competitive than existing competitors who did little beyond cutting corners. The Iranian and the German professors had the professional experience to teach and manage this educational and technological process. To do it right by these means of superior efficiency and safety is not much more costly than error-prone, inefficient, bribe-intensive, cutting corner practices.

Goldbeck the senior and his sons were supportive of the idea, driven by the desire to be socially engaged for civil society as well as a promising market. One of the first orders of Goldbeck the senior when starting his little enterprise had been a cold store in Iran. Learning about Iranian culture and local people in his young days he sympathized with the project and stated: “Iranians need our help and the market there is very promising.” He offered to have a franchising contract later on, when the two professors managed to build a company in Isfahan fabricating as efficiently, safely and reliably as Goldbeck. So both professors decided to adapt this model to the situation in Iran. Saraman’s layout of its production plant is a copy of Goldbeck.

German quality and safety of products is highly recognized and valued in Iran and usually premium prices are paid to acquire such products. Nevertheless, the founders knew that technology transfer alone is not a panacea, especially in the context of a developing country.

SEEDING THE BUSINESS: INVESTING IN KNOW-HOW TRAINING

“Technology includes machines, know-how and procedures. We did not yet import the machines but imported the know-how and procedures”.

Professor Jamshid Parvizian, Iranian founder of Saraman

A major problem with the North-South models of technology transfer is the inadequate investment in local human capital and skills development. Hence, the machinery gets transferred but the ‘know-how’ and procedures required to adapt, develop and sustain solutions remain limited, often to be done by paying high-consulting and after-sales services. Being aware of such pitfalls, before any technology transfer Saraman invested in developing human capital and local know-how. In other words, the first pillar of their business model was local human capacity development. It proved to be a crucial component for further development and adaptation of the technology to the Iranian context. This was done by taking groups of Iranian students and scholars to training courses in Germany, in collaboration with those who developed the construction technologies.

Bringing groups of foreign students and scholars to Germany and providing training to them is a general aim of the German Academic Exchange Service (DAAD). Financially

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16 Deutscher Akademischer Austausch Dienst (DAAD) is a private, federally- and state-funded, self-governing national agency of the institutions of higher education in Germany, representing 365 German higher education institutions.
supported by the DAAD program of the German Foreign Ministry, with a total funding of about 400,000 Euros, Professor Pegels organized annual summer schools in Germany on ‘Affordable Earthquake-Safe Housing in Developing Countries’. Some of the participant experts covered their own expenses. Up to year 2010, about 400 Iranian students, scholars and experts have participated in these summer schools. Working jointly with German engineers and scholars, they learnt about the technical know-how and also provided insights on the ways to adapt the construction solutions to the Iranian context (see fig. 1). German students of Civil Engineering used this chance to build a professional network for international cooperation to be used for their professional lifetime. The summer schools have been integrated into lectures about entrepreneurship in Civil Engineering and Industrial Engineering at Wuppertal University (BUW).

To make this professional vision sustainable and continuous over a long time, in 2004 their respective universities, Isfahan University of Technology (IUT) Iran, and University of Wuppertal (BUW) set up a first Joint Bachelor Programme of Civil Engineering to boost know-how development required for successful technology transfer. In 2009, the faculty of Industrial Engineering of IUT upgraded this Joint Programme BUW/IUT by extending it to Master and PhD students. Both side strongly supported the program.

After developing the necessary human capital and know-how training, Saraman started its business activity in 2007 with two professors, their post-graduate and graduate students and 35 practitioners (expert welders, workers and erectors), who got specific vocational training within the DAAD project as described above.

**COST REDUCTION BY ENHANCING EFFICIENCY**

“We adopted the procedures of safe flaw-less production…We learned how to do it using older machine tools.”

Professor Jamshid Parvizian, Iranian co-founder of Saraman

In order to understand how the use of advanced construction technology, despite its initial high price, reduces the final cost of the construction, first we should take a look at the conventional construction projects in Iran. There are four major costs associated with a construction project: land, construction material, machinery and labour. Saraman utilized technology and process optimization to reduce costs at various stages.
A common way in Iran for financing construction projects is pre-construction sale, where the buyer shares the construction costs before the project begins. Land should be purchased before the construction starts. Here a mix of inefficiency and inflation causes a problem. Due to inefficiencies associated with conventional construction, producing all of the structure on site takes place without machines mostly by low-skill builders. As a result, the construction takes much longer than in Europe and its completion is delayed by some years. This means that an important amount of capital gets locked unnecessarily. Considering the rising inflation in the country, which can get as high as 25%, this translates to increased capital cost and more financial burden. Using advanced construction technology and fully prefabricating in an industrial workshop can significantly reduce the construction time, hence the unnecessary capital lock-up. In addition, the safety of such construction is by far better than conventional construction. There is no production on site any longer, no risky on-site welding. Erection of structures is reduced to assembly only, using bolts.

In line with that approach, Saraman adapted innovative construction methods, a modular design for the industrial production of earthquake-safe structures, strictly separating safety relevant components from non-relevant ones. First, the safety-related structure is fabricated in the industrial workshop of Saraman by engineers and practitioners who had received professional vocational training. There is a strict quality control by the professors and their PhD students. In the next step, the components that are not safety relevant, mainly the infills, can be done by local low-skilled labour to create jobs. Infills are made by locally available, cheap material in an environmentally friendly way. This cheap or free material, such as soft sun-dried adobe, is the cost-cutting feature to compensate for the cost of steel structures to guarantee safety.

It’s like the idea of Henry Ford: by high efficiency of production, production time got reduced, mass production became possible and cars became affordable for the masses. Here, safe steel structures are made affordably by efficient industrial fabrication and professional experts. As a result, the building gets ready faster, the capital does not get locked for too long time and risk of inflation gets mitigated.

The Iranian co-founder summarizes the cost reduction of the Saraman approach compared to the conventional construction as “…for simple residential houses the steel structure is about US$60/m2, and the total cost of the construction, including the piping and kitchen is about US$250/m2. if you compare this with other construction methods, for massive construction, the Saraman product can be 20-40% cheaper. The saving is due to the modular design which reduces scrap, the CAD modeling which makes any re-doing on site unnecessary, and the time saved by fast processing techniques which is against inflation”.

LOCAL ADAPTATION, AWARENESS AND ACCEPTANCE

Urbanization posed a serious problem for Iran. New high-raised buildings around mega-cities like Tehran, ‘vertical villages’, pose the same social deterioration problems as observed in France. Therefore, Saraman limits its housing programme to three storey buildings without need of expensive lifts, maintaining traditional social coherence of inhabitants. Housing in
smaller towns and rural areas is the market Saraman aims at, making living there attractive and generating job opportunities in construction. This may be an efficient contribution to prevent rural exodus and avoid slums.

A major barrier for diffusion of earthquake-proof construction is low awareness about safety. Coupled with traditional construction methods, low awareness gives way to opportunistic construction practices. Fraud imposes the most destructive influence on the safety of structures in developing countries, especially when it comes to housing for the poor. It happens that some constructors illegally leave away components needed for earthquake safety to enhance their profit. Diagonal struts could be left away as long as there is no earthquake. But if an earthquake happens, houses collapse and floors pile up like pancakes leaving no survivors in between.

Localizing the idea of safe construction was crucial for developing Saraman’s innovation and creates demand for it. Construction method of Saraman found a way to address this issue. Making the steel structures that ensure the safety of the construction visible from the outside reduces the chances of cheating. A visible structure has the decisive advantage that the inhabitants of the house – given enough awareness – can check the existence of the structure and its crucial safety components by themselves. Only this way houses will be resistant to the effects of fraud.

To help increasing awareness of civil society about the importance of such structures, the Iranian female students who participated in the summer schools at Wuppertal University proposed a brilliant idea: to cover the steel structures by cover strips with ornaments painted by local artists to emphasize and bring out the visible structure. With help from local artists, civil society has begun to accept the distinct beauty and attractiveness of visible earthquake-safety structures. According to the Saraman founders, diagonal struts are the key static structure to cope with horizontal shocks of earthquakes. The summer school girls gave them a remarkably clear inscription: “I will save your life in case of earthquakes!” (see fig. 2).

Further adaptation took place in design of the construction. German house designs were not compatible with the Iranian culture. The Iranian graduate students got involved in the design process to find out how best the new construction could be adapted to Iranian
preferences (see fig 3). The layout and the accessibility of rooms inside a building are quite different in European and in Islamic architecture. As the safety-relevant structure is at the outside, all rooms at the inside can have an individual layout following cultural aspects of the inhabitants.

Financial model
As a start-up, Saraman had to find ways to mitigate the risk and cost of running its business. Training was a major part of the Saraman business model, but it would be costly to continuously send groups of Iranian students to Germany. Therefore, it was crucial to get the support of DAAD in the early phase. DAAD financed the travel costs and expenses for the training of the Iranian students and scholars in Germany.

Moreover, German engineering companies like Goldbeck, Koester, Kutsch, Kaltenbach, Peddinghaus, ICW and BOCAD that were involved in the technology transfer of construction machinery and CAD/CAM software, offered the Iranian group opportunities for internships in their companies to learn the know-how. In two cases, they even gave machinery and software free of charge so the construction projects could start faster using advanced stud welding technology.

Once Saraman trained enough engineers and workers, the commercial phase began in 2007. A local investor, Mr. Abdolmehdi Edjlali, who had a background of some training in Germany and had successfully founded new enterprises in Iran, provided the initial capital and the land in the Isfahan industrial park to establish the first production plant and start the business. The investment was considered to be one third of the share value; one third was the expertise and working capacity of the German professor and one third the one of the Iranian professor. In the first years both professors invested their time and effort without getting paid for it. This helped to build up financial reserves. A reasonable part of the annual profit was put to the reserves to pay salaries even in times of economic crises and lack of orders. The investor became proprietor of the new halls and enjoyed the rental income.

Saraman made other innovative adjustments to its financial model to succeed in the Iranian context. It is normal for many contractors to postpone the payment to subcontractors as late as possible. In a highly inflated economy, this can reduce the value paid. In contrast to the common practice, Saraman pays immediately when the job is done. This has been the key feature for them because now the best subcontractors are asking to work for Saraman. This way, they also participate in continued vocational training. Besides, in a highly uncertain market, all the local suppliers have special credits for Saraman, as their record has proved guaranteed payment on time. The transparency Saraman practices in all contracts proved to be the source of trust in the customers as well as the employees. Because of high quality and delivering full payment without penalty or withhold on time was achieved. This is rather exceptional in Iran and market prices include such typical losses, which Saraman did not have.
FINDING NICHE MARKETS
At the beginning of starting up its business, Saraman found it a challenge to get financing from Iranian banks. It was difficult for Saraman to offer securities, such as land and offices. All their private assets would be at risk. Saraman relied on its quality of work to get the required funding. To get the initial capital, they tried to find a niche market where they could prove their quality, efficiency, safety and lower final cost. Finally, they found a niche market which would be a perfect place for earthquake-proof construction: school construction.

They learned from Goldbeck’s business model that it is better to start the business phase by conducting projects for clients who could be frequent buyers. With that in mind, in January 2007 Saraman participated in a bid advertised in the newspaper by the State Organization of School Development, which was building new schools every year to be erected in lower income regions. In the call for bid they placed an emphasis on using innovative construction technologies. The Saraman founders saw this as an opportunity to demonstrate the advantages of their method and also start entering the construction market. Starting with school construction had the advantage that it could be scaled up to construct more schools, once Saraman proved its advantages. It would also fit the social values of the founders. These schools would be a visible teaching example of earthquake safety to help in acceptance of the new design by civil society and in the long-run open the market for earthquake-safe housing (see Fig 4).

Nevertheless, for a start-up like Saraman entry to commercial markets was not an easy one. As the Iranian co-founder, Professor Parvizian recalls: “We won the bid, but had no real experience in handling problems like material supply, transport, human resources, insurance and so on. The first weeks were quite a mess. I did not sleep for several nights sometimes to solve daily problems of the workshop. The main problem however was the rise of the steel price by 40% in a couple of weeks, between winning the bid and signing the contract.”

Despite the financial challenges, Saraman invested in building trust with its core business partners in the hope of creating a long-term relationship. “Most contractors halted their projects during the time when the price of raw material raised by 40%. We have been one of the rare small enterprises that delivered the product some weeks earlier claiming no extra payment. The profit was not too much, but the credit was enough that I became a trustable consultant for the school organization of Isfahan. The next projects all came from this organization.”

Figure 4: Earthquake-proof structure for a dormitory and school in Khoor, one of the most remote towns of Iran with only 6,000 inhabitants (Source: courtesy of Saraman)
To convince local proof engineers and professional colleagues about innovations was quite a challenge. Established competitors did not like to lose contracts to a newcomer that had innovative ways without usual bypasses and cost-cutting omission sins. Once the start-up demonstrated the viability of robust construction in a much more efficient way, they got more orders from other clients to design or construct hospitals, dormitories, sport halls and a technology centre.

Financial gains were immediately invested in personnel, new equipment and facilities. The good job that they did gave way for more construction projects. Therefore, it became possible to finance the enterprise by running income instead of asking bankers for credits.

**CONSTRAINTS AND SOLUTIONS**

Saraman faced a number of constraints when trying to use advanced technology in the context of Iran. The main challenge was lack of **knowledge and skills** on both the supply and demand side. The new technology required certain skills which were not available. Despite the fact that there are a significant number of young graduates and engineers, the know-how required for working based on Saraman’s approach was lacking. Other knowledge constraints were business and marketing skills. The founders were from academia and lacked the special skills needed for business management.

The most important constraint on the supply side was lack of cost-consciousness among Iranian designers: They often do not consider the final cost and the financial consequences of their design. To mitigate this problem, the work of the designers are pre-checked and fully modified by the German professor and engineers to avoid unnecessary costs.

The contractors and sub-contractors were also not familiar with the benefits of Saraman’s method compared to conventional approaches, and chances were that they might also resort to usual cost cuttings which were widespread in the sector. Therefore, the German professor invested his time in raising the awareness of the public construction contractors about construction safety issues. He offered evening lectures to the school organization. About 40 employees of the organization participated in those evening lectures and got interested in that approach to improve safety of schools, reduce cost and speed up delivery. Vivid discussions among engineers often continued till late at night. The idea, not only to talk about it, but to do it, found overwhelming acceptance. The decisive key market of earthquake safety was opened. Other public constructions like hospitals, followed after inspecting the contractors’ references. Customers’ satisfaction proven by word of mouth proved to work well to win more customers in Iran. To enable sub-contractors, a German member of the team teaches high-quality welding on site in the workshop of Saraman in Isfahan. So, these welders become expert welders proud of being the best welders around and updated regularly by new, innovative technologies.

On the demand side, lack of knowledge about earthquake-safe construction and the ways to verify it was a barrier to its adoption among the clients. In low-income markets, clients often tend to ignore safety measures in favour of lower costs. Another knowledge-related constraint
was the traditional view on technology among some of the authorities who decide on large-scale construction projects.

**Physical infrastructure** was another barrier. To implement the construction method in its optimum way, certain machinery was required. The ones that existed in Iran were old and new ones could not be imported due to the embargo on Iran.

Access to only limited **financial resources** was a constraint for which Saraman as a start-up had to seek innovative solutions. There were major costs associated with the training, construction method and machinery. Although Saraman managed to find external funding for training and reduced construction costs by enhancing efficiency, getting finance from the banks for importing the machinery remained a major obstacle. Despite all financial limitations, they tried hard to be punctual in paying their subcontractors, which eventually worked in their favour and created a high level of trust and loyalty.

Although there are **regulations** for monitoring construction by independent parties, often constructors try to find ways to cheat the monitoring system and buyers about safety. This is more problematic knowing that in conventional construction methods; users cannot verify the safety of the house themselves. Introducing visible safety structures, that reduces chances for fraud combined with local awareness raising about safety measures, was a way to combat fraud and lenient monitoring practices.

### Table 1: Constraints and Strategies of Saraman’s Business Model

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<th>Constraints</th>
<th>Strategies</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial Resources</td>
<td>Engage in policy dialogue</td>
<td>The German founder of Saraman engaged in dialogues with German institutions that had funds for developing countries and got finance for training Iranian students.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Through several presentations for the State Organization for School Development, Saraman convinced them about the advantages of their method to build earthquake-proof schools. They got a niche market in school construction that would provide finance and awareness needed to develop their business.</td>
</tr>
<tr>
<td></td>
<td>Combine resources and capabilities with others</td>
<td>The financial constraint of training got eased by linking to the funded trainings in Germany and also finding German construction companies that were willing to provide on-site training free of charge.</td>
</tr>
<tr>
<td></td>
<td>Invest in removing constraints</td>
<td>Instead of using inefficient conventional construction methods, Saraman invested in advanced construction technology that would eventually lead to lowering costs by enhancing efficiency.</td>
</tr>
<tr>
<td></td>
<td>Adapt products and process</td>
<td>By adapting modular construction and applying efficient methods, speed of construction got enhanced. Use of locally available material like adobe infill reduced the costs further. Both factors resulted in</td>
</tr>
</tbody>
</table>
## The Business and its Relationships

As described in the previous section, Saraman’s business model has three main components: technology transfer, know-how transfer and adaptation (localization) of construction solutions. The main actors that contributed to the development of the business are listed below.

**German Academic Exchange Service (DAAD):** supported by the German Foreign Ministry had a programme to foster ‘German – Arabic/Iranian Dialogue of Universities’. This provided an opportunity to train the Iranian students and scholars in Germany. Annual summer schools started, and were visited by more than 300 students coming from earthquake-prone developing countries. Later on, joint bachelor and master programmes were initiated between the two universities in Isfahan and Wuppertal, with financial support from DAAD.

**German and Iranian founders:** The professors involved did not restrict themselves to teaching theory only, and founded the start-up enterprise in Isfahan to give an example proving the correctness and feasibility of the business idea ‘To build affordable, earthquake-safe homes and schools creates many local job opportunities..
Having a network of academic and corporate contacts, the German professor played a key role in linking the Iranian group to the finance, technology and know-how required for developing a safe construction business. On the other hand, the academic reputation and local trust and network that the Iranian professor had, was the key-feature in implementing and adapting the initiative in Iran.

**Local investor:** A local investor in Isfahan, who himself had been trained in Germany and had successfully founded enterprises in Iran, offered the land needed for the Saraman start-up and financed the first infrastructure. He owns the new production halls and receives the rental income.

**German engineering companies:** A number of German engineering companies, like Goldbeck, Koester, Kutsch, Kaltenbach, Peddinghaus, ICW and BOCAD supported the technology transfer as mentioned above. Their motivation was driven by a sense of corporate social responsibility and also trying to create a presence in a potential market.

**Iranian engineering companies:** To implement the construction project and make the technology work there was need for additional expertise. For that purpose local engineering companies were approached to provide services like engineering consultancy and monitoring. Currently, Saraman cooperates regularly with six other local companies as their main suppliers. They supply steel, welding materials, cranes, painting materials, and transport services.

### Results Created by the Business

“Generating environmental and social impact through the motto: ‘Building Homes and Schools with visible Earthquake-Safety Creates Jobs in Construction,’ is the unique selling argument of Saraman.”

Professor Georg Pegels, co-founder of Saraman

The two professors who founded Saraman, have shown that even in very difficult economic circumstances, new spin-off enterprises can be started from scratch if there is entrepreneurial energy. Since its foundation in 2004, the enterprise provided design office, detailing office and industrial workshop step by step. Potential and vision to grow up to more than 2,000 employees will be realistic when the financial crises in Iran fade out.

### ECONOMIC RESULTS

In a sector where cutting costs through cutting corners, sacrificing quality and safety has become widespread, Saraman managed to become profitable by not following suit. Instead, it distinguished itself by cost reduction through systematic production and efficient use of advanced technology that is transferred through vocational training. As the German co-founder argues:”To do it right by the means of superior efficiency and safety is not much more
costly than error-prone, inefficient cutting corners not fully paid or compensated by expensive bribing.”

Job creation within the company was the most direct and visible economic result of Saraman. This happened in two ways: first, those engineering students who got training in summer schools, got lucrative job offers to help with implementing similar projects in Iran. Their engineering background, boosted by advanced training in Germany and their knowledge of the local context proved valuable for those who were implementing such construction projects.

Many university graduates struggle to find an appropriate job right after their studies. The Saraman initiative played a positive role in developing and productively using the knowledge of local graduates and creating employment opportunities for them, who later got employed in Saraman and other companies. This proved to be a much better approach compared to paying huge salaries to foreign engineers to do the same job, often with less local adaptation due to unfamiliarity with the context. On the other hand, more construction projects provided more job opportunities to less skilled unemployed labour who are directly and indirectly involved.

Second, in addition to employment opportunities within Saraman, hiring of sub-contractors has an additional economic benefit as the Saraman approach fuels economic growth through entrepreneurial opportunities in the construction sector.

As discussed earlier, the local construction sector, mainly using conventional construction methods and technologies, was not able to meet the increasing need for housing, let alone making them safe. The mediocre quality and delivery delay typical in conventional constructions, which fuels the rising housing prices, does not help the economy. It happens from time to time that such constructors, stuck with their inefficient processes, stop paying their employees and suppliers or even leave the building site letting the customer down. In such a situation, Saraman jumps in and serves its new customers by unprecedented quality, reliability and fast delivery. Thanks to better efficiency and some redesign, the final cost is usually even lower than that of the original constructor. Such success generates new loyal customers. Even in difficult economic times, the customers for school construction projects were paid in due time and have ordered next structures because they did not want to lose such a reliable supplier.

In the first years the aim was to develop human capital and afterwards to grow in terms of number of customers and the value of contracts. The first project, to build a school in Mashad, started in January 2008. The value of the contract was US$350,000.

Since starting its business activity, Saraman has got offers from about 30 clients. The projects include design and detailing projects as well as fabrication. The biggest design projects have been several hospitals around the country. Among the fabricated projects, there are six schools, two dormitories, and two sport halls. The biggest project so far, with a floor area of
8,000 square meters has been a research center for the small to medium enterprises (SMEs) in the city. The list of Saraman projects and their value is provided in table 2.

Table 2: Saraman projects

<table>
<thead>
<tr>
<th>Construction Project</th>
<th>Contractor</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fabrication Projects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School in Mashad</td>
<td>Mashad School Organization</td>
<td>300,000 Euros</td>
</tr>
<tr>
<td>School in Largan</td>
<td>Isfahan School Organization</td>
<td>70,000 Euros</td>
</tr>
<tr>
<td>School in Oshtorgan</td>
<td>Isfahan School Organization</td>
<td>70,000 Euros</td>
</tr>
<tr>
<td>School in Jay</td>
<td>Isfahan School Organization</td>
<td>70,000 Euros</td>
</tr>
<tr>
<td>Kashan Dormitory for students</td>
<td>Isfahan School Organization</td>
<td>100,000 Euros</td>
</tr>
<tr>
<td>Khoor Dormitory for students</td>
<td>Isfahan School Organization</td>
<td>65,000 Euros</td>
</tr>
<tr>
<td>Khoor School</td>
<td>Isfahan School Organization</td>
<td>110,000 Euros</td>
</tr>
<tr>
<td>Daran School</td>
<td>Isfahan School Organization</td>
<td>60,000 Euros</td>
</tr>
<tr>
<td>Jahadabad School</td>
<td>Isfahan School Organization</td>
<td>32,000 Euros</td>
</tr>
<tr>
<td>Residential Building</td>
<td>Private owner</td>
<td>104,000 Euros</td>
</tr>
<tr>
<td>R&amp;D Center for SMEs of Isfahan</td>
<td>Organization to develop industrial towns</td>
<td>1,600,000 Euros</td>
</tr>
<tr>
<td>School gathering hall</td>
<td>Shahrreza Technical school</td>
<td>60,000 Euros</td>
</tr>
<tr>
<td>School sport hall</td>
<td>Fazli Charity and School Organization</td>
<td>280,000 Euros</td>
</tr>
</tbody>
</table>

| Design and Detailing Projects               |                                        |             |
| Sanandaj Hospital                          | Medical University of Sanandaj         | 70,000 Euros |
| Masahd Hospital                            | Mashad University                      | 80,000 Euros |
| Several schools and halls for students     | Isfahan School Organization            | 40,000 Euros |
| Ahvaz Hospital                             | Ahvaz Medical University               | 20,000 Euros |
| The research center for Green Energies     | Isfahan University                     | 85,000 Euros |
| Several educational and student sport centers | Kermanshah School Organization       | 7,000 Euros |

Currently, the company has 12 permanent employees in its office and more than 65 workers in different fabrication and implementation sites. The second year revenue, with about 100% increase from the year before, was about 3.2 million Euros (US$3.9 million). Table 3 shows the growth of the start-up.

Table 3: Business growth of Saraman start-up

<table>
<thead>
<tr>
<th>Year</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Contracts (Design, detailing or fabrication)</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Revenue (US$)</td>
<td>1,900,000</td>
<td>3,900,000</td>
</tr>
<tr>
<td>Permanent employees</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

17 In this case, Saraman offered a non-profit contract. This was however a chance to test and deploy new technologies in assembly and roofing.
<table>
<thead>
<tr>
<th>Temporary employees</th>
<th>22</th>
<th>65</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit (US$)</td>
<td>30,000</td>
<td>110,000</td>
</tr>
<tr>
<td>Investment in machines and tools (US$)</td>
<td>20,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Production Capacity (tons/year)</td>
<td>800</td>
<td>1,800</td>
</tr>
<tr>
<td>Design and Detailing Capacity (tons/year)</td>
<td>7000</td>
<td>14,000</td>
</tr>
<tr>
<td>No. of Business partners</td>
<td>21</td>
<td>27</td>
</tr>
</tbody>
</table>

**SOCIAL RESULTS**

Starting off with constructing earthquake-safe schools can eventually help to raise awareness in society about the innovative look and feel of buildings with a visible guarantee of earthquake safety. Schools with visible earthquake safety are a teaching example for civil society to change from unsafe constructions to this new design that looks quite different from buildings done in the past.

Changing the preferences of civil society to opt for earthquake safety is a difficult social step requiring time, good examples (as schools are) and endless powers of persuasion. Civil society gets the values of efficiently made and thus affordable safe homes as well as many local job opportunities, for instance to complete the infills of the structure.

The majority of the schools Saraman constructed were used by the children of low-income families, who had to go to schools with less-than-adequate safety measures before. On the other hand, when the engineers at State Organization of School Development, got convinced by the efficient and reliable methods offered by Saraman, they decided to have more of such schools. The excellence of this organization was spectacularly proven during the Bam earthquake: Their schools coped with the earthquake and were used as a shelter the days after for people who survived but lost their homes.

Saraman has also created awareness about safe construction measures among other construction contractors. It is still a difficult process of working culture to educate design engineers and detailers to regard not only technical feasibility but also cost responsibility for their solutions. This cost consciousness of professional experts in the design and detailing process will help to make products affordable for the poor. To measure this progress, the total cost of alternative solutions are not simply estimated but exactly calculated before and after execution. This is a novelty in Iran and unique up to now.

International professional cooperation is a source of Germany’s welfare and exports as well as a source to improve the welfare of civil society in developing countries. Both sides enjoy this win-win situation. With high level of commitment and energy, the two professors worked very hard to design the Joint Program BUW/IUT and to get it started, solving some mission impossible. Professor Pegels and Professor Parvizian recall the nice sense of achievement when they got invited to give a presentation at the 2009 NAFSA (Association of International Educators) conference in Los Angeles to report about their DAAD-supported project, under the title: ‘The German Response to 9/11’.
ENVIRONMENTAL IMPACT

Conventional construction technologies on site not only prolong the construction time by years, but also have negative environmental effect. Excessive use of construction materials like cement produced in a more energy consuming process than steel is common in such methods. Traditionally, cement is used for all big building components, complete walls and floors. Therefore much more cement than steel is used. Cement cannot be recycled, steel can. In addition, due to lower safety measures, such buildings get easily demolished in case of an earthquake and leave a large environmental impact.

The most significant technical issue of unsafe buildings is the widespread use of walls made of brittle hollow bricks without any steel bracing. Horizontal earthquake shocks crack such brittle walls from corner to corner and the wall fully disintegrates out of plane. This way all columns lose their horizontal stabilization and fall over like dominoes letting the floors pile up in a ‘pancake collapse’ leaving no survivors. Moreover, the heavy debris adds to environmental pollution.

Therefore, the product development of Saraman uses safe steel frames stabilized by eccentric diagonal steel struts and cheap, shock-damping adobe infills, which is much more environment friendly. The new method utilized by Saraman uses locally available adobe. Adobe is not only cheap or free in rural areas but also has the advantage of being processed by sun-drying only with no extra energy requirement, which makes it an environmentally friendly technology compared with traditional production of construction components. No polluting cement factories, no expensive machines on site and no fuel consuming equipment are needed for local adobe material.
Growth Strategy and Future Outlook

As Saraman has successfully demonstrated the advantages of its construction solutions, it gets more projects from clients. They aim is to use their accumulated market knowledge and credit gained from public projects to penetrate more into housing market. Saraman has the potential and vision to grow to more than 2,000 employees. This will be realistic when the actual global economic crisis and the specific financial crises in Iran due to the international sanctions and local economic politics fade out.

Enhancing the awareness of the Iranian engineers and contractors about the new technologies of housing will remain the core for Saraman activities. At the same time, improving the understanding of the ordinary people about the problem of safety and quality in buildings is a critical factor that needs to be worked out. Saraman’s founders had in mind to erect a small museum for earthquake safe designs in one of the central parks of Isfahan. Initially they had the support of the municipality of Isfahan, but the building has not yet been built due to the actual, severe economic crisis.

Since the company is founded by academics, marketing and other business management skills remains a challenge for them. Currently, the quality of their work is their main competitive advantage that helps them gain markets and they benefit from young energetic graduates who have good management skills to handle marketing tasks.

Saraman’s initial idea was making affordable housing for the lower income communities. After proving their abilities in the niche market of public construction, they plan to get closer to this aim by entering the bids for upcoming housing projects that government is going to announce for lower income communities.

They want to grow and enter mainstream construction projects after the embargo on Iran is called off and the Computer Numerical Control (CNC) production lines can be imported and installed. Although currently the Iranian team uses older technology to do the job, having the CNC lines can enhance productivity and efficiency by a factor of at least ten. Considering the fact that similar housing challenges are faced in many other developing countries, from the early stages the founders of Saraman had the international market of developing countries in mind. With the rapid reconstruction in neighbouring countries Iraq and Afghanistan, it could be an opportunity for them to enter the construction market of such countries.

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18 CNC production systems are systems in which production machines use CAD/CAM. This increases precision, speed and flexibility of production.
References

**INTERVIEWS**
- Professor Jamshid Parvizian, Isfahan University of Technology, Iran, interviewed on 2nd and 10th March 2010
- Professor Georg Pegels, University of Wuppertal, Germany, interviewed on 23rd March 2010 and updated 5/5/2010

**PUBLICATIONS**

**WEBSITES**
– Iran Urban Studies, (2007),
The case was completed in May 2010 and released in 2011. The information presented in this case study has been reviewed by the company to ensure its accuracy. The views expressed in the case study are the ones of the author and do not necessarily reflect those of the UN, UNDP or their Member States.

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Design: Suazion, Inc. (NJ, USA)

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