How complexity restored Bali’s rice yields

In Bali, rice is so intrinsic to the culture that its indigenous name, nasi, is also the word for “meal.” For 1,000 years farmers on the Indonesian island province determined planting and irrigation schedules for Bali’s curving rice terraces in ritualized water temple ceremonies.

By the 1960s, however, rapid population growth forced Indonesia to begin importing rice from abroad, and in the mid 1970s the Asian Development Bank and the Indonesian government introduced modern agricultural methods to boost crop production. In Bali, this meant new high-yield varieties of grain and the use of chemical fertilizers and pesticides.

The new rice — dubbed “miracle rice” — and chemicals increased Bali’s rice production exceedingly well — for a short time. The bumper crops began to wane in less than two years. The modern approach, on the other hand, required each farmer to plant rice as often as possible, which made it easier for rice pests to migrate across adjacent, continually planted fields, and it caused the supply of irrigation water to become less predictable.

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There’s no monolithic period of collapse but a lot of variability,” says SFI President Jerry Sabloff. “What we see are many variable patterns. The only way to explain the variability is to have a complex systems view.”

Jerry and Arizona State University geographer B. L. Turner have woven together a complex, catastrophic stresses. In recent years, for example, many archaeologists have renewed their interest in the drought hypothesis, says Jerry. That interest has been fueled by more and better paleoclimate data from the region. What the data show, however, is not a simple drought/collapse relationship, he says. Even sites that were water-rich, like Palenque, collapsed.

“It is true that we go through moments when certain drivers are emphasized much more than others,” says Turner. “But collapse of the Classic Maya is sometimes simplified to the point of misunderstanding.”
Nonlinearities From the editor

We recently hosted a public panel discussion at Santa Fe Institute. Why complexity is a defining feature of our universe. The event was moderated by David Krakauer (who could probably talk provocatively about cardiology if you asked him to). With big names in science, like Lord Colin Renfrew, Sir Christopher Llewellyn Smith, Murray Gell-Mann, and Melanie Mitchell (who literally wrote the book on complexity), the conversation was no disappointment. Many people had to be turned away, unfortunately, because of a full house and those pesky fire codes. You can now watch it online at www.santafe.edu.

SFI President Jerry Sabloff lamented disappointment. Many people had to be turned away, unfortunately, because of a full house and those pesky fire codes. You can now watch it online at www.santafe.edu.

SFI External Professor Herbert Gintis. As we repeated these simulations,” says Steve. “This is almost always the case, indeed, statistically significant, with p-values of less than 0.05. “The main issue with studying homicide, and other violent crimes is that numbers are usually small, usually a small number per 100,000 people, which doesn’t reveal much underlying truth about variations in crime between cities and over time.”

Additionally, notes co-author Andres Gomez-Lievano, a graduate student at Arizona State University, “The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics” says Luis. "The deeper level of understanding made possible with our new method might, if considered by policy makers, contribute to making real progress in fighting crime, especially in taking into account its variability and helping unravel its underlying dynamics.”

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Defining archaeology's biggest questions

What is the relationship between agricultural production, population, and innovation in human history? How do humans respond to abrupt environmental changes? How does the organization of human communities emerge from and constrain the actions of their members?

During a workshop at SFI in August, participants asked and began to hammer out answers to these and other big questions in archaeology.

The National Science Foundation funded the workshop, with an objective of defining the key scientific questions that will drive archaeological research over the next decade, says Keith Kintigh, the workshop's organizer. The archaeologists who participated sought to articulate challenges that are both relevant to human communities today and central to the history of our species.

"While these types of 'science serves art' or 'art serves science' projects can be very fruitful, what have generally been missing are collaborations that truly advance both art and science, and society," she says. "An extended, deep, critical discussion about the potential opportunities for science and art collaboration and exchange is urgently needed."

SARC is organized by Richard Lowenberg, director of the 1st-Mile Institute, and Jack Ox, associate research professor in the University of New Mexico College of Fine Arts. It is part of the 18th International Symposium on Electronic Art, which takes place in Albuquerque, Santa Fe, and Los Alamos September 19-24, 2012 (http://www.siae2012.org).

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Taking stock of Darwin's theory

In his Auto Immune Response (AIR) series, artist Will Wilson addresses the relationship between a post-apocalyptic Greenpeace and the beautiful but toxic environment he inhabits. Auto Immune Response Laboratory 2, seen here, is a hogan-shaped metal greenhouse that will cultivate Indigenous food and dye species. The greenhouse will be installed at the Nasactivate National Zoo in Window Rock, Arizona. (Courtesy: Will Wilson)

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Two centuries ago, a young Charles Darwin puzzled over the birds of the Galapagos Islands while gathering the inspiration for his theory of natural selection. Today that theory is getting a fresh look through the lens of information theory.

In essence Darwin’s theory is the process by which living things with traits favorable for reproduction in particular environments succeed in doing so. On a planet where complex biological and physical pressures are always – to some degree – in flux, natural selection leads to a steady evolution in the contest between organism and environment.

“Although the theory of natural selection is simple, it remains endlessly contentious and difficult to apply,” says Steven Frank, an SFI External Professor and professor of ecology and evolutionary biology at UC Irvine. He is publishing a series of articles in the Journal of Evolutionary Biology called “Topics in Natural Selection,” addressing the fundamentals of the theory.

“My goal is to make more accessible the concepts that are so important, yet are either mostly unknown or poorly misunderstood,” he wrote.
Online ‘social petri dish’ offers insights about real-world human mobility

New research started during SFI’s 2010 Complex Systems Summer School suggests that player-interaction data from online games such as Pardus are surprisingly useful for understanding how and why people physically move in the real world.

Large amounts of data on human mobility are readily available thanks to studies of mobile phone records and location-based online social networks. But a rich understanding of the mechanisms behind the individual decisions people make – based on socio-economic factors, spatial constraints, and temporal considerations – has been elusive.

CSSS participants Michael Szell, Roberta Sinatra, Giovanni Petri, and Vito Latora, working with SFI External Professor Stefan Thurner, used the vast amounts of data on players’ social interactions and economic activities generated by Pardus to study the patterns and mechanisms of player mobility. Pardus is a multiplayer online game in which gamers explore a virtual universe, where they make friends and enemies and communicate, trade, and interact with one another.

“What I like most about this work is that human mobility in the real world and in virtual worlds are not all that different,” Stefan says. “One could – if one is a bit generous – interpret this to mean that the processes of traveling basically happen in our imagination, and the way mobility is finally executed is somewhat secondary; we don’t necessarily need the real world to understand how we move.”

The team’s results were published in June 2012 in Scientific Reports, an online, open-access journal by the Nature Publishing Group.

The American Association of Physics Teachers (AAPT) has selected SFI Science Board member David Pines with the John Daniel Jackman Award for Excellence in Gradiate Physics Education. The award is presented to physicists and physics educators who have made outstanding contributions to curriculum development, mentorship, or classroom teaching in graduate physics education. David will receive the award at the AAPT’s January meeting in New Orleans.

For creativity to thrive, it must be nurtured. Mickey and Jeanne Klein have long nurtured the creative spirit through their long-time support of contemporary art. Recently, they discovered that the same creative spirit is alive and well at SFI.

“It struck me how much I’d like to support not only arts but creative thinking...to honor the creative spirit no matter the discipline,” Jeanne says. “At SFI, they acknowledged that the creative spirit crosses disciplinary lines.”

Jeanne used to think of science in terms of its disciplines – astronomy, biology, nuclear science, and the like. That changed last September when she and Mickey attended their first SFI public lecture. SFI External Professor David Krakauer’s Ulam Memorial Lectures on the co-evolution of biological intelligence and machine intelligence opened their minds to creative thinking that transcends and unites traditional scientific disciplines. Even more impressive, Jeanne says, was how David spoke in a way that was engaging and understandable to nonscientists.

The Kleins move comfortably in the world of contemporary art. They find that people who are new to art are often interested in what they see but afraid to discuss it. Science can have a similar effect; people without a science background are often curious but intimidated.

Jeanne says she and Mickey have appreciated the way SFI has opened its doors to the uninformed public. Its researchers are not only willing to share their work but they are eager to explain it in a way that nonscientists can understand and get excited about.

“I love that they’ve reached out to people,” Jeanne says. “Great minds attract great minds, no matter the discipline.”

Housing bubble continued from page 1

find coarse patterns rather than apply the full range of possibilities.

“There are millions of homeowners with widely different tastes and wealth,” says SFI External Professor John Geanakoplos, an economist at Yale. “Aggregating them into a simple average misses the behavior in the tails that causes the big swings up and down like we saw from 1997 to 2009.”

In a recent paper published in American Economic Review, John, SFI External Professors Rob Axtell and Doyne Farmer, and Peter Howitt of Brown University questioned weaknesses in the current models and asked whether forecasters were using the most telling variables. Their own agent-based model of the U.S. housing market, they wrote, better captures the heterogeneity of agent behaviors.

Their model adds new loan features and incorporates data on household demographics, economic conditions, and housing market behaviors. Starting at the level of the individual homeowner, it follows each through the various costs, likelihood of prepayments and turnovers, and other factors. Its simulations nearly fit housing prices and other housing market indices from 1997 to 2010.

Consequently, they say, manipulating the model (by holding certain variables constant) offers a means to pinpoint the major causes of the 2008-2009 crash. Freezing interest rates, for example, simply reduced the intensity of the boom and bust, but holding leverage (down-payment percentage) constant greatly shrunk the boom and wiped out the bust.

“Knowing that mortgage lending with very small down-payments was the primary cause of the 1997-2006 housing boom, and that the sudden spike in required down-payments in 2007 and onward was a primary cause of the housing cash, suggests that the federal reserve ought to rethink its obsession with interest rates as the unique tool for maintaining financial stability,” says John.

Support for SFI’s 2012 lecture series is provided by Los Alamos National Bank.

Upcoming events


The Museum of Contemporary Native Arts and SFI kick off a new lecture series exploring the creative process in art and science. SFI Distinguished Professor Geoffrey West and native artist Mateo Romero discuss how creativity influences and inspires their work, how it differs and differs across art and science, and how the discovery process – whether it be in painting, photography, or mixed-media art or the study of scale in physics or social systems – can produce bursts of manic, creative energy that drives innovation. Moderated by SFI’s Valerie Flane Wilson.

SFI’s Stanislaw Ulam Memorial Lectures: “The Many Faces of Complexity,” three lectures, three nights, October 2-4, 7:30 p.m., James A. Little Theater (1060 Cerrillos Road), Santa Fe. Renowned scholar, science activist, zoologist, and complex systems pioneer Robert May, Baron May of Oxford, discusses the complex systems that matter most to humanity’s future. May is a professor of zoology at Oxford University and Imperial College, the former president of Britain’s Royal Society, the former Chief Scientific Advisor to the U.K. government, and a member of SFI’s Science Board.

Lecture I (October 2, 7:30 p.m.): “Beauty and Truth in Mathematics and Science” – May explores the extent to which beauty has guided, and still guides, humanity’s quest to understand how the world works with a bird’s eye view of the interactions among beliefs, values, beauty, truth, and our expectations for tomorrow’s world.

Lecture II (October 3, 7:30 p.m.): “What Is Stability in Today’s Complex Financial Systems?” – The economic crisis prompts May to explore how we might design financial services that satisfy their purpose of efficient distribution of capital in a free-market system but without the fragility and hidden costs of our current systems, with emphasis on what ecology can teach us about banking.

Lecture III (October 4, 7:30 p.m.): “People and Tomorrow’s World” – What has more people on Earth, with each of them having a longer life span and greater per-person impact on our environment, means for the world’s climate and ecosystems and the services they deliver (with emphasis on how little we know about these questions).